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ANNOTATED BIBLIOGRAPHY AND STATE-OF-THE-ART REVIEW OF THE FIELD OF TEAM TRAINING AS IT RELATES TO MILITARY TEAMS

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The purpose of this report is to give a broad overview of the field of team training as it relates to military teams. It includes an annotated bibliography and state-of-the-art review of research bearing on team training which covers the time period from 1955 to 1980. Critical conceptual and methodological issues are discussed in the review and discussion is focused on team performance rather than human relations variables. Categories of the annotated bibliography are organized to support the review. These include

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PREFACE

The present annotated bibliography of team research and state-of-art review focus on team and small group research relevant to the description, assessment and training of military, primarily Army, teams. In general, military teams refer to small, formally defined military units of approximately two to eleven persons who normally perform their tasks in an interactive and interdependent manner. Examples of Army teams are Infantry rifle squads, combat Engineer squads, tank crews, bridge sections, Redeye teams, howitzer batteries, maintenance teams, and helicopter crews.

Articles in the annotated bibliography are categorized and cross-referenced by category in order to give the reader an appreciation for the major questions that have been addressed. The areas covered include theories and models of team behavior, variables that affect team performance, military team training studies, methodological tools to assess team processes and products, studies on the characteristics of effective and ineffective teams, and previous reviews of small group and team research. Within each of these areas, the focus is on team performance variables. Human relations variables (e.g., leadership, team spirit, cohesiveness) were outside the scope of the review. The time period covered was from 1955 to 1980. The reference entries in the annotated bibliography are longer than is typically the case, in order to give the reader a better understanding of each article.

As with other state-of-art reviews, this review includes summaries and evaluations of research findings that bear on team training. However, it also focuses on critical conceptual and methodological issues that must be addressed. Thus the reader is given a broad overview of the field as it relates to military teams.

Introduction

In previous reviews of small group and/or team research, the authors (Boguslaw & Porter, 1962; Collins, 1977; Denson, 1981; George, 1967b; Glaser, Klaus & Egerman, 1962; Goldin & Thorndyke, 1980; Hall & Rizzo, 1975; Klaus & Glaser, 1968; McGrath & Altman, 1966; Meister, 1976; Wagner, Hibbits, Rosenblatt & Schulz, 1977) have stressed that one of the major conceptual problems in the area of team research is the definition of team itself. There is no accepted definition, although the definitions that have been proposed (Glaser, Klaus & Egerman, 1962; Hall & Rizzo, 1975; Klaus & Glaser, 1968; Wagner et al. (1977) often do not differ greatly, as indicated in Denson's (1981) recent review. Usually, the issue of team definition has been raised by reviewers of the area, rather than by the researchers themselves. Few researchers have explained why they have called the groups they studied "teams," leaving the reader in the difficult position of making his own determination. Two related definitional problems exist as well, that of defining team tasks and team skills.

Such definitional issues are not trivial. How does one decide if researchers are really studying the same entity? Without some consensus regarding definition both basic and applied research efforts are greatly hindered. Accumulation of knowledge about teams cannot occur, resulting in few or no theories about team functioning and a disorganized collection of research findings that the practioner must attempt to apply.

The following definition of team is used in this review:
A team consists of

a) at least two people

who

b) are working towards a common goal/objective/mission

where

c) each person has been assigned specific roles or functions to perform

and where

d) completion of the mission requires some form of dependency among the group members.

Dependencies can be explicit (e.g., direct verbal communication among team members or physical interaction among members) or implicit (e.g., members learn when and how to react to the actions of other members without formal signals and even learn to anticipate such actions). This definition is not presented as definitive, but was used when examining the studies cited in the annotated bibliography.

The definition is very similar to that cited by Hall and Rizzo (1975) except that it excludes their formal team structure requirement. Although the review will focus on military teams, particularly Army teams, the above definition is not restricted to such units. It does,

however, distinguish teams from small groups in that individuals within small groups are less apt to have assigned roles or functions, and dependencies among members are not essential to small group processes. Studies of teams as well as small groups that approximate teams are included in the annotated bibliography.

Military teams have other characteristics that distinguish them from the groups investigated in laboratory research studies and from small groups within private or public organizations. Some of these characteristics make military teams similiar to athletic teams.

1. At least two types of military teams exist. Some military teams have a history; they are not constructed on an ad hoc basis. Although individual team members may belong to a specific team for different periods of time, this history means that members develop expectations about each other and establish procedures for working together. Other teams are task-organized; team members are selected because they possess the requisite skills for solving a problem, e.g., maintenance crews. These individuals may or may not have worked together before.

2. The size of military teams can vary greatly. The hierarchical nature of military organizations makes it difficult to determine team size limits, e.g., a rifle team is part of a rifle squad, which in turn is part of a rifle platoon and so on. Military judgement must be used in defining team boundaries. This review will focus on teams at and below the platoon level (Army nomenclature).

3. The "formal" team, as defined in military documents, will not always correspond to the "active" team, in that, the number of individuals who interact with each other at a given point in time varies with the task. Thus even though the rifle squad may be formally identified as a team, for a particular task or mission only three members may be actively involved in "teamwork."

4. Although the previous definition specified that team members work toward a common goal, the definition of goal is relative (e.g., for a rifle squad "prepare a defensive position" is a larger goal than "dig your foxhole"). In addition, military teams often are assigned different tasks (e.g., rifle squad: movement to contact mission vs. defensive mission vs. reconnaissance patrol) which may require different degrees of involvement from team members and different forms of "teamwork."

5. Members of military teams not only are assigned specific positions, they also work within a formal structure where leaders and subleaders are determined on the basis of rank and

experience. This formal structure influences the nature of member interaction and the way jobs are peformed.

6. Prior to joining an active military unit members usually receive extensive individual training for their respective positions. The amount and type of team training received within an active military unit can vary greatly from unit to unit.

7. When a layman thinks of teams, he may visualize football or basketball teams where the degree of teamwork or coordination among members is fairly high, as compared to a track team in a mile relay, where team interaction is limited to the baton hand-off (critical as it may be). With military teams the frequency and criticality of such interactions and dependencies vary greatly with the task and with the nature of the team. The type of interactions (e.g., verbal vs. nonverbal) among members will also vary.

8. Almost all military teams work with some type of equipment. In some instances, the equipment itself strongly determines the size of the team and the nature of team member interactions.

9. Military teams must constantly face turnover in team membership.

10. Some military teams (e.g., tank crews, rifle squads) must constantly train for a situation that they hopefully will never have to face -- combat. On-the-job training for such situations is impossible. For other military teams, mainly those involved in the support of combat (e.g., maintenance teams) on-the-job duties do not differ greatly from those faced in combat itself.

11. During the conduct of military missions, military teams constantly receive some form of feedback on the appropriateness of their actions. The immediacy, visibility, and completeness of this feedback, however, depend upon the task being performed and the structure of the team.

The problem of defining a team task has received relatively little attention by researchers. Given the previous definition of a team, it follows that a team task is one whose completion requires dependencies between at least two members of a team. One of the difficulties in reviewing small group and team research studies is that tasks that do not require more than one person have often been used in such research, e.g., problem solving tasks, some of the Ohio State University studies on combat information centers. Can generalizations be made from such research tasks to situations where more than one person is required to complete the task?

Finally, reviewers and researchers have often implied that there is a distinction between individual and team skills, but they have not identified this distinction. Unless this difference is clear, attempts to train team skills have little meaning. Dyer (1980) distinguished between the two as follows: individual skills refer to activities that could be or are performed independently of other team members, while team skills refer to activities/actions that are performed in response to the actions of other team members or that guide/cue the actions of other team members.

The following state-of-the-art review will address what is known about military teams (primarily Army teams) and what major questions remain unanswered. The major categories used in this summary are presented below. Within each category both the questions that have been addressed and those that have not been addressed are presented.

1. What theories have been proposed to account for team behavior?

2. What types of task do teams perform?

3. How do teams function or work; by what means or processes do teams achieve their goals?

4. What procedures have been developed for measuring team performance, team processes, and other team characteristics?

5. What factors influence team performance?

6. What has been the impact of training programs on team processes and performance?

7. What training recommendations have been made for military teams?

8. What questions and methodological issues need to be examined in order to improve team training and assessment?

WHAT THEORIES HAVE BEEN PROPOSED TO ACCOUNT FOR TEAM BEHAVIOR?

There are no comprehensive theories of team/small group behavior that have been developed systematically and tested empirically. Instead, most researchers have generated descriptive models, that fail to specify the principles, postulates, and hypotheses about relationships among variables that are characteristic of theories (McGrath & Altman, 1966), or have developed miniature models and theories that focus on only certain aspects of team functioning.

An example of a general team model is the systems input-process-output approach (Hackman & Morris, 1975; Knerr, Berger, & Popelka, 1980; Roby, 1968; Shiflett, 1979). Knerr et al. specified three types of input (organizational and environmental variables, individual input variables, and team input variables); team processes were classified as adaptation, orientation, communication, etc.; and team output was based on Steiner's (1966, 1972) concept of actual productivity being a function of individual productivity minus process losses associated with task communication and coordination requirements. Shiflett's model referred to resources (knowledge, ability, and skills possessed by individuals attempting the task), transformers (variables that impact upon resources and determine the manner in which they are incorporated into output variables), and outputs. Hackman and Morris (1975) viewed group performance as affected by three major variables: effort expended on the task by group members, task performance strategies used in carrying out the task, and member knowledge and skills. The group interaction process was postulated to affect these variables, in that where individual skills are important in determining group performance, process loss (i.e., Steiner) is apt to be low; but in situations where obtaining a solution involves complex teamwork or subtle social processes, process loss is apt to be high. Investigation of this interaction between input and process and its relationship to group output has been the primary thrust in much of Hackman's empirical work.

The most complex and detailed general input-process-output model is that developed by Roby (1968). Roby's work was based on both military teams and small group laboratory research. The model assumes that group performance results from input to the group from the task environment, at which time such observations are "digested" and placed in the service of an "executive" faculty, which in turn relates the input information to the group's goals and tactics, producing prescriptions for group action or behavior. The result is an instrumental action which modifies the task environment and initiates a new performance cycle. Four input subfunctions relate to the processing of information by the group: observation, information routing, storage and forecasting, and patterning. Three functions handle the cumulative effects of actions, the pacing of the performance cycle, and procedural changes during continuous group performance, mapping and planning, addressing, and phasing. The two output subfunctions, action potential and executive structure, affect overall team performance.

Roby's discussion of his model is particularly interesting because he raises many research questions about team behavior that need to be addressed. For example, with the information routing subfunction he noted that it is rarely the case that complete dissemination of all information to any group member is desirable or feasible. With respect to the storage and forecasting function such questions as how individuals determine which information is essential, how information is retained, and how these functions are divided among group members were raised. Similarly, patterning deals with how "raw" observations are transformed into useful forms for the team. Scattered bits of information may never get collected into a whole, and a critical problem may be the appropriate and timely dissemination of information. In terms of the functions that control continuous activity, the addressing subfunction includes learning of special roles by members, and the phasing subfunction focuses on coordination of member activities. Problems in this latter area include formalizing the phasing requirements for certain tasks, describing the group's learning of these requirements, and specifying the signaling system requirements for specific phasing relations.

The scope of other models and theories is smaller than most input-process-output models, yet some have influenced small groups and team research. Boguslaw and Porter's (1962) distinction between emergent and established situations has had an inpact upon researchers working in military training (Denson, 1980; Dyer, Tremble, & Finley, 1980; Wagner, et al., 1977). Alexander and Cooperband (1965) proposed that teams learn differently in these two situations; specifically, that a stimulus-response model applies to established situations and an organismic model applies to emergent situations. The organismic model is very similar to Taylor's (1979) cybernetic view of group functioning and Hackman's (1969) discussion, as all postulate the existence of similar processes by which groups plan activities and adapt to their environment. Yet researchers have really not applied these theories to the development of team training programs. If the conditions that foster team performance do in fact vary with the established-emergent nature of the team task, then presumably the corresponding training programs should differ as well. One of the stumbling blocks in this areas may be the lack of procedures for discriminating emergent from established tasks.

The Henriksen et al. (1980) and Shriver et al. (1980) works represent one effort to apply different learning theories and techniques to the training of different team leader skills. In general, they distinguished between emergent and established tasks. They focused specifically on the acquisition of team leader skills (primarily Infantry squad and platoon leaders) required in combat-like settings. Five major leader skills were identified (management, communication, problem-solving, tactical, and technical). Experiential (learning by doing processes) and analytic (cognitive-verbal processes) learning conditions were judged to be the best settings for learning all the leader skills except technical skills, which were judged to be easily handled by individual methods of instruction.

Obviously, all military teams do not perform the same task. The emergent-established distinction is just one way of classifying tasks which can serve as a basis for developing theories of group behavior. Steiner (1972) identified different types of tasks based on how individual efforts are combined to form a group product: disjunctive, conjunctive, additive, discretionary, compensatory, complementary, and divisible. The concept of conjunctive and disjunctive tasks was also used by Thibaut & Kelly (1959). Shaw (1976) proposed that group tasks differ on the following dimensions: difficulty, solution multiplicity, intrinsic interest, cooperation requirements, population familiarity, and intellectual-manipulative requirements. Dieterly (1978) discriminated between tasks not dependent upon a team context and those that did depend upon use of a team. Within the latter category he described four task characteristics: whether the task is unique to a team position, whether the task is expected to be accomplished by a specific member, whether completion of a task depends upon completion of another task by another member, and the degree to which tasks can be reallocated during team functioning. Finally, Naylor and Dickinson (1969) posited team performance to be a function of task structure (e.g., complexity of information-processing requirements), work structure (way in which task components are distributed among members), and communication structure (communication patterns developed by members to complete the task).

Most attempts to represent team/group behavior mathematically have been based on Steiner's (1966, 1972) concept of actual productivity as a function of potential individual productivity minus process loss (see also Lowe & McGrath, 1969; Shiflett, 1979). The mathematical formula for actual productivity varies with the type of task. Other efforts at modeling team behavior are illustrated by Siegel's (Siegel, Wolf & Fischl, 1969; Siegel, Wolfe & Consentino, 1971) computer simulation of Naval crews.

Coordination among team members is one part of the group process. Thibaut and Kelley (1959) specified some factors that affect the amount and nature of coordination within a group (group size, individual ability to grasp the nature of group dependencies); George (1967b) distinguished between teams and crews in terms of coordination requirements (emphasis on sequential responses, extent to which required responses can be predicted); and Jordan, Jensen & Terebinsky (1963) presented a four stage model of the development of cooperation. Tuckman's (1965) model of small group development (forming, storming, norming, and performing) postulates that interpersonal relationships must be established before the group can focus effectively on accomplishing the task at hand. The extent to which this sequence holds true for military teams as well is, of course, an empirical question.

In summary, the theoretical base regarding team behavior is meager. Roby's model, however, does raise many important research questions; questions reflecting the complexity of team behavior which have been neglected or treated superficially by others under the rubric of

coordination or teamwork. The distinction between emergent and established tasks appears to be relevant to military teams and may have implications for team training methods.

Steiner's concept that actual team productivity is a function of potential individual productivity minus group process loss means that group processes always have a negative effect on group output. As mentioned later in this review, Shaw's (1976) modification of the concept of actual productivity to reflect gains as well as losses from the group process is more general and is more valid. Steiner based his formula on small group tasks which can often be completed by one person, yet many military tasks require more than one person. In such military situations the group process has positive, not negative, effects on group outcome.

It is interesting to note that McGrath and Altman's 1966 observation on the lack of theories on team behavior holds true today. Yet such developments, developments that go beyond descriptive models, are necessary if group behavior is to be understood and predicted, and if training programs are to have lasting effects.

WHAT TYPES OF TASKS DO TEAMS PERFORM?

Small group researchers (e.g., Altman, 1966b; Hackman, 1968; Roby & Lanzetta, 1958; Steiner, 1972) have stressed that group processes and performance are strongly affected by the group task, and that understanding the nature of the task will help greatly in understanding team performance. Altman stated the problem as follows: "It is not enough to merely say that a given X-Y relationship holds for task A, but not for task B. We need to know the essential properties of the two tasks so as to be able to link the behavioral differences to the task characteristics. In short, we need to develop an understanding of the fundamental parameters in terms of which tasks can be described so as to be able to more systematically map between tasks and between behavior and task characteristics" (p. 200). Perhaps the strongest research evidence for the statement that tasks influence performance comes from small group studies conducted by Hackman and others (Hackman, 1968; Hackman, Brousseau & Weiss, 1976; Hackman & Vidmar, 1970; Hackman, Weiss & Brousseau, 1974; Kabanoff & O'Brien, 1979; Kent & McGrath, 1969; Sorenson, 1971). They have demonstrated that different types of intellectual small group tasks (production, discussion, and problem-solving) can account for up to 50 percent of the variance in group performance measures.

One of the major hurdles in identifying task parameters involves the definition of task in terms of its scope, e.g., reference may be to a specific behavioral act such as putting a mortar in the gun tube or to the entire mortar situation such as firing a smoke mission. In addition, there is the question of the extent to which task definitions should reflect the degree to which tasks are redefined by team members as opposed to restricting the definition to "externally imposed" tasks. Hackman (1969), however, has argued that the latter issue is basically

irrelevant to the problems of identifying task parameters since both objectively defined tasks and redefined tasks can be described and differentiated along the same dimensions. The first issue, that of task breadth or scope, however, has not been adequately resolved in most analytic schemes developed for classifying tasks.

Task Classification Schemes

Five task classification schemes are cited below. Unfortunately, the overlap among these approaches is difficult to determine and there have been no systematic attempts to apply these approaches to military teams in order to determine which is (are) most fruitful. The variety of approaches used also indicates the complexity of the problem.

Hackman (1969), Fleishman (1975), Wheaton (1968), and O'Brien (1967) summarized, in different ways, the general schemes used by researchers in describing tasks. Hackman cited four approaches: task qua task approach (describing the physical nature of the task, its subject matter, characteristics of stimuli involved, the objective properties of tasks); task as a behavior requirement (identifying the responses that should be emitted in order to achieve some degree of success); task as a behavior description (describing the responses actually emitted); and task as an ability requirement (specifying patterns of personal abilities or characteristics required for successful task completion). Both Fleishman and Wheaton repeated Hackman's behavior description, behavior requirements, and ability requirements categories but added a task characteristics category which referred to intrinsic, objective, properties of tasks identified through task component analyses and rating scale procedures. O'Brien presented three approaches: task-task (task considered as a system with component parts and relations; division into subtasks and the relations that order subtasks, e.g., flow charts); task-organization (tasks described by how groups must organize their activities); and task-person (tasks described by relating the characteristics, responsibilities and abilities of group members to specific task characteristics). O'Brien's task-person category appears to include Hackman's and Fleishman's categories of tasks as a behavior requirement and task as an ability requirement.

Altman (1966b) proposed a hierarchical scheme for describing group tasks. At the lowest level are behavioral acts (e.g., persons A and B mutually exchange information). At the next level are broader behavioral requirements (e.g., kinds of interaction required to complete a task successfully, processing, cooperation, attending, orientation). Finally, intrinsic task properties are described (e.g., stimulus input rate, equality of information distribution).

Finally, Roby and Lanzetta's (1958) approach provided another perspective on group tasks. They presented a two-dimensional scheme for describing what they called "molecular task properties." One dimension involved a four-stage cycle of task events: task input (e.g., stimuli from the environment), group input (group activities that focus on collecting and disseminating information), group output (activities

made in response to relevant stimuli -- decisions, commands, motor responses), and task output (environmental conditions affected or modified by group activities). The other dimension described each of these stages according to three properties: descriptive aspects (qualitative and frequency descriptions), distribution of events in physical space or with regard to other events, and the functional behavior of events in terms of their occurrence over time or as a result of preceding events. This approach was assumed to provide a comprehensive and detailed description of any task. Roby and Lanzetta stated, however, that a molecular description provided little basis for conveying the meaning of tasks in psychological terms or for comparing tasks. They proposed the concept of "critical demands" to bridge the gap between molecular task properties and social psychological variables.

What are the similarities among these various approaches? A tabular summary is given in Table 1, where eight different approaches are identified. Altman's lowest level of behavioral acts corresponds to Hackman's tasks as behavioral descriptions and Roby and Lanzetta's group input/ouput descriptive stages. Altman's behavioral requirements level corresponds to Hackman's task as behavior requirement category, is part of O'Brien's task-person category, and corresponds to Roby and Lanzetta's concept of critical demands. Altman, Fleishman, and Wheaton postulated the category of intrinsic task properties, and at times the descriptions of stimulus input (Roby & Lanzetta) seem to be at this level. Hackman's (1969) task qua task category (describing patterns of stimuli) corresponds to Roby and Lanzetta's task input stage, primarily the descriptive and distribution dimensions. Several individuals described tasks in terms of the individual abilities that are required (Hackman, Fleishman, Wheaton, O'Brien). O'Brien was the only one concerned with describing how subtasks are combined to accomplish the overall task (his task-task category), and how personnel must organize themselves to accomplish the task (his task-organization category). Finally, only Roby and Lanzetta discriminated among group tasks in terms of their environmental impact.

Task Classification Schemes and Task Distinctions Made by Team Researchers

How do these general approaches to classifying tasks relate to specific descriptive techniques used in examining small units/teams? Unfortunately, the general approaches do not provide guidelines for application. Even though two researchers may describe tasks at the behavioral act level, their descriptive categories may easily differ. None of the specific research techniques reviewed for this bibliography was systematically based on the general approaches cited by the previous authors. Some techniques represented only one descriptive category; others represented several categories.

Table 1

Correspondence among Task Description Approaches

General Approaches					Research Examples
Altman	Hackman	Fleishman, Wheaton	O'Brien	Roby & Lanzetta	
Behavioral Acts	Task as a Behavior Description	Behavior Description	- - - - -	Group Input & Output at the description & distribution levels	Hammel & Mara (1970) Daniels et al., (1972) Helm (1976)
Behavior Requirements	Task as a Behavior Requirement	Behavior Requirements	Task-Person (Responsibilities)	Critical Demands	Warnick et al. (1974; Hackman (1968); Lord (1976); Tuckman (1967); Shaw (1963, 1976); Hammel & Mara (1970)
Intrinsic task Properties	- - - - -	Task Characteristics	- - - - -	- - - - -	Glaser, Glanzer & Morten (1955)
- - - - -	Task qua task	- - - - -	- - - - -	Task Input	Daniels et al.(1972)
- - - - -	Task as an Ability Requirement	Ability Requirement	Task-Person (abilities)	- - - - -	Shaw (1963, 1976)
- - - - -	- - - - -	- - - - -	Task-Task	- - - - -	Steiner (1972); Klingberg et al. (1967); ARI studies (1962-1970)
- - - - -	- - - - -	- - - - -	Task-Organization	- - - - -	George (1977); Glaser, Glanzer & Morten (1955)
- - - - -	- - - - -	- - - - -	- - - - -	Task Output	- - - - -

Among the techniques that represented primarily one descriptive category were the following: Steiner's (1972) classification of tasks as disjunctive, conjunctive, additive, etc. represents O'Brien's task-task level. This is also the case with researchers who have investigated parallel and serial tasks (AIR studies, 1962-1970; Kingberg et al., 1967). The human factors task-analytic approach (systems analysis) generally reflects the behavioral requirement category. In such analyses the behaviors required for adequate performance of specific system tasks are specified (e.g., Warnick et al., 1974, analysis of tank company, platoon, and crew-level tasks). Hackman's (1968) division of intellectual tasks into production, discussion, and the problem-solving areas and the structured-unstructured task continuum used by Lord (1976) and Tuckman (1967) also reflect the behavioral requirement approach, although the behaviors described are at a broader level than those described with the systems approach. George's (1977) distinction between teams and crews in terms of member structure and member role flexibility reflects O'Brien's task-organization category. From George's viewpoint, if each member in a group/unit has a unique speciality then that group is completely structured (a one-to-one ratio of members to roles). On the other hand, if every member has exactly the same role speciality, the group is completely unstructured. Flexibility of structure is estimated from the probability of role interchange in an operational environment. George preceived teams as highly, but flexibly structured units (e.g., Infantry rifle squad), whereas crews are highly, but less flexibly structured units (e.g., aircraft and tank crews).

Among the techniques that represent several descriptive approaches are the following:. Shaw's (1963, 1976) task dimensions of difficulty, solution multiplicity, intrinsic interest, cooperation requirements, intellectual-manipulative requirements, etc. seem to represent both the behavioral and ability requirement categories described by Hackman. Glaser, Glanzer, and Morten's (1955) categories for describing the communication links within Navy teams, e.g., link frequency, concurrent activity, process differentiation, input magnitude, sequence probability, intra-team dependence, and output irrevocability, reflect both Altman's intrinsic property category and O'Brien's task-organization category. Hammell and Mara (1970) distinguished between military decision-making skills and decision-making tasks in that several decision-making tasks can reflect the same decision-skill. Decision-making tasks reflect Altman's behavioral requirements level. Daniels, Alden, Kanarick, Gray and Feuge (1972) analyzed tasks performed on Navy training devices into molecular stimulus, cognitive, and response elements. This approach reflects Roby's and Lanzetta's task input, group input, and group output stages, particularly at the descriptive level.

A summary of the relationship between the general classification approaches and research examples of the approaches is cited in Table 1. Team research could probably be improved if researchers used one or more of the task classification approaches cited here. It is clear that the different approaches yield different descriptions of team tasks.

However, further work is needed to determine which approaches are most fruitful for investigating various team problems (e.g., team development, training, measurement).

HOW DO TEAMS FUNCTION OR WORK; BY WHAT MEANS OR PROCESSES DO THEY ACHIEVE THEIR GOALS?

A flippant answer to these questions would be -- "through teamwork." Despite all the small group research, one sometimes feels that that in fact is all we do know - it's just teamwork. Relatively little research effort has been devoted to carefully examining such issues as how do team members interact with each other; do such interactions vary over time, with the situation and/or with team experience; what do team members learn as they work together; do effective teams behave differently from ineffective teams; what is the meaning of such terms as teamwork, coordination and cooperation; and what is the role of the leader in team behavior. Work in this area is difficult to summarize because there is little intensive investigation of these questions and the approaches vary greatly. Conceptual efforts to describe or characterize team processes will be presented first, followed by more specific procedures used to describe the flow of work within a team, particularly verbal communications, and some work on the role of the military leader in team processes.

Conceptual Efforts

Nieva, Fleishman, and Rieck (1978) identified four major functions that specifiy what a small group does interactively to accomplish an objective: orient, organize, adapt and motivate. Orientation referred to processes by which information necessary to task accomplishment is generated and distributed to group members. Such information may pertain to team goals, team tasks, and member resources and constraints. Organization referred to processes necessary for the group members to perform their tasks in coordination with each other, including such aspects as pacing of activities, coordinating responses, sequencing activities, assigning priorities to tasks, balancing the team load among team members, and matching members to task requirements. Adaptation referred to processes that occur as members accomplish the task, such as compensatory performance and timing, and mutual evaluation and correction of error. Motivation referred to defining team objectives related to the task and energizing the group towards those objectives (e.g. development of team performance norms, reinforcement of task orientation). There was no attempt by the authors to apply these concepts to military teams.

In contrast, work by Glaser, Glanzer, and Morten (1955) on describing the nature of team interactions was done with military teams. They focused on describing the communication links within Navy teams. Communication was defined very broadly as all interactions between team members (e.g., verbal command, hand signal, a checked-out piece of equipment) necessary for accomplishing a task. Some very interesting concepts regarding the team process were generated in this study, and

mathematical definitions were provided for most. Concepts directly relevant to team processes are presented below:

Link frequency: the complexity of the team's communication structure.

Concurrent activity: the extent to which members of a team act simultaneously.

Process differentiation: the extent to which team operations are differentiated into the following six activities - observing, relaying, manipulating, computing, deciding or supervising.

Sequence probability: degree to which the course of team activity can be predicted.

Intra-team dependence: extent to which a team generates the inputs which go to its members - extent to which a team is self-contained.

Communication significance: extent to which certain team members are central points for receiving and transmitting messages.

Supervisory ratio: extent to which a team includes members who function primarily in supervisory capacity.

Anticipatory cuing: extent to which cues are available that "warn" team members that their turn to act will occur at some subsequent time.

Urgency: speed and pressure requirements under which team operation occurs.

Saturation: extent to which a team is likely to receive inputs at a greater rate than it can handle adequately.

Unfortunately, no one else has investigated these concepts further in either small group or military settings.

Several individuals have elaborated on the concepts of team cooperation and coordination. O'Brien (1968) distinguished between two forms of cooperation -- collaboration and coordination. Collaboration was defined as the extent to which different positions are allocated the same subtasks, whereas coordination was defined as the extent to which subtasks allocated to different positions need to be sequenced by definite precedence relationships. Krumm (in Hood et al., 1960) differentiated between two forms of aircrew coordination: mechanical coordination where individuals must synchronize their actions according to standard operating procedures, and response improvisation, where crew members must interact to solve problems for which a stock answer is not available. Miller's (1958) concept of situational interactions reflects another form of coordination. Situational interactions were defined as

interpersonal contacts that are determined by the regular flow of work and are so routinized that no verbal or gestural communication takes place - the situation dictates the timing and nature of interpersonal contacts. Miller considered this type of interaction the highest and most efficient of cooperation. George's (1979) concept of spontaneous coordination, coordination performed by team members on their own initiative rather than as a result of a leader's order, is similar to Miller's concept of situational interactions. It should be obvious to the reader that many different concepts of cooperation and coordination have been proposed and that the measurement techniques used to define these concepts could possibly be quite different from each other.

Techniques for analyzing the flow of work within teams usually assume the form of flow charts that indicate which team members interact with each other, the sequence of the interactions, and the verbal-nonverbal nature of these interactions (Boldovici, 1979; Glanzer & Glaser, 1955; Thurmond & Kribs, 1978). With both Glanzer and Glaser's and Thurmond and Kribs' systems each member's acts were coded as inputs, process or output. For Glanzer and Glaser each act was also classified according to the following content categories: observation, relay of information, manipulation, decision, computing, and/or supervising.

Verbal Communication

Research approaches for examining verbal communication within teams frequently yield mathematical summaries of the sequence and/or pattern of such communications (e.g., Leavitt, 1951; Glanzer & Glaser, 1959). Various indices have been developed that describe the extent to which messages are either received by or sent to a small number of individuals, indices which reflect the amount of information that comes either directly or indirectly to a particular group member, etc.

Other reseachers, particularly those involved with military teams, have attempted to describe what team members talk about during the conduct of a mission. About as many different content analysis schemes exist as there are research studies. Based on small group research Altman (1966a) classified verbal communications as asking, informing, inferring, repeating, evaluating, and telling or ordering. McRae (1964) used a broader classification scheme for verbal communications within problem-solving groups: organizational interactions (procedural and motivational statements), task-specific interactions (action statements requesting and giving information), and residual (all other) interactions.

Brown (1967) analyzed the content of messages sent during Ranger patrols as a function of mission phase, mode of communication (e.g., voice, radio, hand and arm signals), and the initiator and recipient of the message. Message content was divided into two major areas: commands and information. Within each of these areas, content was coded as movement, security, fire, intelligence (command content only) or identification (information content only), command and control, and equipment considerations. Frequency of the messages varied with mission

phase; the patrol leader and assistant leader initiated most of the messages; the command messages were directed towards the entire patrol; as might be expected the leader received few command messages; and the leader, assistant leader and point man served as the nucleus for messages not directed to the entire patrol. Command messages were primarily movement commands, and secondarily those involving command and control of personnel. Information messages focused on personnel status reports and identification of terrain features and personnel. In a similar analysis Siskel et al. (1965) found that aircrew communication content and communication patterns among crew members varied with the mission.

Siegel and Federman (1973) measured 30 verbal communication variables in a study of anti-submarine warfare helicopter crews. A factor analysis of these variables yielded the following four factors. Probabilistic structure of communication referred to extrapolative and data extensive communications - communications that involved the weighing of alternatives and searching for answers to unresolved problems. Evaluative interchange contained direct requests for information and opinion as well as the responses to such requests. Hypothesis formation involved interpretations of past performance in the mission and the evaluations of future tactics to be followed. Leadership control reflected leader communications that defined goals and set a proper atmosphere for crew functioning. In another study of aircrew communication, Williges, Johnston and Briggs (1966) classified the content of communications within simulated aerial intercept teams as either declarative or tactical statements. Declarative statements contained information that was redundant with visual information displays; while tactical statements and commands conveyed information not directly obtained from the display and requests for action from a radar controller to his partner.

Obermayer and others (Obermayer, Vreuls, Muckler, Conway & Fitzgerald, 1974; Obermayer & Vreuls, 1974) measured other aspects of communication that they thought were important to combat aircrew performance; in particular, timing of messages, accuracy of the message, brevity of the message (should not exceed channel capacity), information content transmitted per unit of time, number and frequency of communications. They did find that experienced crews communicated less than inexperienced ones during routine operations, but communicated more frequently during weapon delivery. The researchers recommended that a standard vocabulary be used in order to reduce the length of aircrew messages.

Leader Role

Within military teams the leader often plays a critical role in directing team processes and actions. Analyses of leaders' roles are often couched in terms of tactical expertise; tactics that are specific to the mission and the team, rather than general leader functions or roles that could apply to many military teams. The ARI studies of the effectiveness of REALTRAIN with armor and infantry units reflected the

tactical expertise approach and only indirectly reflected general dimensions of importance (e.g. Meliza, Scott & Epstein, 1979; Scott, Meliza, Hardy & Banks, 1979). However, Henriksen et al. (1980) identified general skills required by small-unit leaders which affect the team process: management, communication, problem-solving, tactical, and technical skills. For example, two basic communication skills were cited: transfer of information, both planned and new, to all appropriate individuals during the condcut of an operation, and pursuit of needed information and receipt and openness to new information. Such skills help to describe the team process in terms of the leader's role.

Studies on Changes in Team Processes

The previous articles focused primarily on ways of describing team processes and how teams function, and did not necessarily address some of the other questions raised at the beginning of this section on how team processes change with team experience or with training, what members learn as they work together, and if and how effective teams behave differently from ineffective teams.

Studies that have described the team process as a function of experience or training indicate that changes within a team have been conducted. In the Rand system research laboratory Air Defense experiments (Biel et al., 1957; Chapman et al, 1959) crews performed more effectively with experience in that they learned procedural shortcuts, reassigned functions to crew members, learned to distinguish relevant from irrelevant information and increased their motor skill performance. In a study of leader training for rifle squads, Poot et al. (1979) found tactical improvements in squad performance (e.g., dispersion among members was maintained in order to avoid heavy casualties from direct fire, communication and control was maintained even over terrain that prevented eye-to-eye communication) as well as general changes in teamwork (e.g., individuals learned the importance of formal team structure as reflected in the chain of command, of the need to know details of the mission/task, were able to function when leaders became casualties, and in general there was an increase in the amount of automatic responses among team members, i.e., George's (1979) concept of spontaneous coordination). Siegel and Federman (1973) found differences in communication patterns within helicopter crews as a function of crew training.

Although the studies just cited found what one might call improvements in team processes with experience and/or training, decrements can occur under stressful, sustained operation conditions. The ARIEM studies (1978-1980) on sustained operations (approximately 80 hours) within Field Artillery fire direction centers showed that the number of incompleted missions increased, members were less able to handle preplanned missions thereby actually increasing their workload with time, more mistakes were made, and longer times were required to process fire missions. Such decrements were more characteristic of teams with inexperienced than experienced individuals.

Training conditions evidently affect what team members learn and how readily they can adapt to other situations. Briggs and Johnston's (1966) study of simulated combat information centers indicates that teams do adapt to the performance criteria established for them during training and find it easier to switch to a more simple than to a more complex criterion. In working with rifle squads George (1967a) found that training conditions that required coordination affected team performance as well as the nature of the teamwork that occurred (e.g., members began to automatically take over a key role when a casualty occurred within the squad, members attended to cues from both the environment and from the team). He stressed that coordination must be trained in order for it to occur under the pressure of evaluation and/or combat situations.

In summary, the limited progress in describing how teams work or function reflects the lack of techniques and procedures that have actually been developed, and the diversity among the few techniques that have been used. No single descriptive procedure has been employed extensively or has been widely accepted by the research community. Although the use of flow charting techniques to describe the work flow of units at a molecular level is commonly used within structured military contexts; it has often been restricted to front-end analyses in the development of training devices or programs rather than in studying processes teams actually use when performing assigned missions.

Unfortunately, the few studies that examined team processes as a function of experience or training used measurement procedures unique to the situation examined, rather than basing them on a general conceptual scheme such as that developed by Nieva et al. (1978), Glaser et al. (1955) or O'Brien (1968). Thus it is difficult to generalize across studies regarding the similarity in team process changes as a function of experience and/or training.

WHAT PROCEDURES HAVE BEEN USED FOR MEASURING TEAM PROCESSES, TEAM PERFORMANCE, AND OTHER TEAM CHARACTERISTICS?

Measurement is critical to the future of team research. Too often, findings must be qualified due to the unreliability of measurement procedures, failure to measure the appropriate variables, lack of measures for some variables, and/or errors in administration of measurement instruments. The success of a research effort is often determined by the quality of the measurement tools.

Team Processes

Several general procedures have been used to describe and measure team processes. These are listed below with a brief indication of some situations in which they have been applied.

1. Content analysis of team communications: Analysis of information center communications with a focus on tactical messages (Briggs & Johnston, 1966b); Ranger patrol messages (both verbal and nonverbal), content was coded according to movement, security, fire, intelligence, identification, communication and control, and equipment within each mission phase -- who sent and who received messages was recorded as well as the mode of communication (Brown, 1967); communications dealing with task-specific interactions vs. organizational interactions (McRae, 1964); content analysis of communications within helicopter crews, based in part on Bales interaction analysis and Osgood's semantic differential, factor analysis of 30 communication variables was performed (Siegel & Federman, 1973); content analysis of verbal communications during simulated radar-controller aerial intercept tasks (Williges, Johnston & Briggs, 1966).

2. Mathematical indices of team processes based on field observations of member interactions: Indices describing the nature and extent of communication links among team members (based on Navy teams) such as link frequency, communication frequency, concurrent activity, sequence predictability and communication significance (Glaser, Glanzer & Morten, 1955); indices summarizing communication or interaction links based on matrix algebra, indices of concentration and status (Glanzer & Glaser, 1959); indices of collaboration and coordination based on structural role theory (O'Brien, 1968).

3. Other Field Observation Techniques: Field observation procedures for describing team behavior, sampling of that behavior, and the technical means for data collection vary with each study. Sometimes observations are made by military experts, sometimes by research personnel, and sometimes a permanent record is obtained through video and/or audio tapes. Behavior can be recorded in terms of military tactics, time to complete activities, individual vs. team tasks, movement patterns, target detections, errors committed, etc. There are no standard or commonly used procedures, probably because of the great

variety of teams and team missions that exist. Such observation techniques have been used to study Infantry rifle squads (Havron et al., 1955; Root et al., 1979; Scott et al., 1979; ARI REALTRAIN studies, 1978-1980), Engineer assault ribbon bridge sections (Dyer, 1980), and Field Artillery fire direction centers (USARIEM, 1978-1980).

4. Task Analysis: Use of flow decision-response diagrams to represent tank crew interaction sequences (Boldovici, 1979; Warnick et al., 1974); identification of aircraft crewmember roles, duties and tasks (Helm, 1976).

5. Computerized simulation of teams: Process modeling of computerized Field Artillery fire direction centers (Connelly, Comeau & Steinheiser, 1980).

6. Interviews: Interviews of instructors or team leaders to identify such factors as errors made by team members during a mission, and how and when errors were corrected (Glanzer & Glaser, 1955).

Team Outcomes

Measures of team output also vary. However, the techniques used actually represent a limited number of measurement procedures. These general procedures are cited below with examples of situations where they have been used.

1. Ratings of proficiency based on observations of team performance: Infantry squads (Dees, 1969; Havron et al., 1955); Army units from the squad to the battalion level -- ARTEPs (Havron et al., 1978-1979); Naval carrier air traffic control centers (Finley et al., 1972); Naval antisubmarine rocket teams (Schrenk et al., 1969). In most cases ratings were made by military personnel rather than research personnel.

2. Time to complete tasks: Air defense crews (Baldwin, Frederickson & Hackerson, 1970); Infantry squads (Dees, 1969); Naval carrier air traffic control centers (Finley et al., 1972); Mortar sections and Field Artillery batteries (Giordano et al., 1977; Horley & Giordano, 1970; King et al., 1980; USARIEM, 1978-1980), Engineer assault ribbon bridge platoons (Dyer, 1980).

3. Accuracy/Errors: Impact errors, azimuth errors, plotting errors, etc., in mortar sections and Field Artillery batteries (Giordano et al., 1977; Horley & Giordano, 1970; King et al., 1980; USARIEM, 1978-1980); Naval carrier air traffic control centers (Finley et al., 1972); number of target misses/hits in tank gunnery exercises (Warnick & Kubala, 1978; Wheaton et al., 1978).

4. Number and type of omitted and incompleted tasks: Field Artillery fire direction centers (USARIEM, 1978-1980).

5. Frequency counts on other variables: Consumption or quantity used -- number of weapons expended by Navy anti-submarine rocket teams (Schrenk et al., 1969); number of vehicular and/or personnel casualties in combat units such as Infantry squads and armor/mechanized Infantry units (Sulzen, 1980; ARI REALTRAIN studies, 1976-1979).

6. Measures of knowledge: Tactical knowledge test for Infantry rifle squads (Havron et al., 1955).

Other Team Characteristics

Measures of other team characteristics have tended to focus on indices of team cohesion (Clark, 1969; McGrath, 1961; Nelson & Berry, 1968). Frequently, these indices have been derived form sociographic techniques. One interesting variable that has been measured with Infantry squads is the extent to which a team member is team- or self-oriented (HumRRO, 1971; Olmstead et al.,1971). This instrument, called the Team Task Motivation Questionnaire, is one of the few paper and pencil instruments developed within this area of military team research. It could be easily adapted to teams other than the rifle squad.

Measurement Issues and Recommendations

The measurement problems in the area of team research are not easy to solve. Although improvements are being made, undoubtedly individuals will find faults with these efforts. One of the underlying difficulties is that of defining team tasks and skills, as mentioned earlier in this review. If the content or domain of interest is not clearly defined, then measurement specialists will always have problems, and critics will have adequate justification for their criticisms. Kubala (1978) and Warnick and Kubala (1978) have stressed the importance of applying measures to tasks that really are team tasks. Another difficulty, not unique to team measurement, is that in some cases measures are developed for variables that are easy to examine, not necessarily variables that are judged as critical or representative of mission success or sensitive to the independent variables under study (Connelly, Comeau & Steinheiser, 1980). The complexity of some team tasks makes both process measurement and the interpretation of outcome measures very difficult. Kubala (1978) has mentioned the conflict in obtaining process and outcome measures for assessment and diagnosis within combat teams. Process data are needed to provide feedback to training personnel, while outcome assessments meet the demands of field commanders. Yet it is difficult to obtain process information from typical two-sided field exercises. Although process information can be obtained from a one-sided test, it is difficult to obtain outcome information of the kind desired by commanders from this type of test. Practical problems arise due to the limited resources available for even one type of test.

The traditional measurement problems of reliability and validity exist withn team measurement, and the importance of carefully

implementing measurement procedures applies as well (Knerr, Root & Word, 1979). As with measures of individual skills, inconsistency in performance may be produced by variables other than the criterion measure (Horrocks, Heerman & Kalk, 1959). For example team training may not be long enough to produce stable performance, or individual team members may learn at different rates and therefore produce unstable team performance. An interesting study by Medlin and Thompson (1980) on military judges' ratings of armor/anti-armor unit performance indicated that their ratings were based on only an evaluative dimension. The results could have been a methodological artifact. On the other hand, the general dimension may have occurred because all aspects of unit tactical skills may really change in unison, or that judges use a general dimension because they do not know what other dimensions to consider, how to assess performance on other dimensions, or how to assimilate information from other dimensions to arrive at a single evaluation of unit performance.

A major area overlooked by measurement specialists, perhaps because it is so difficult, is that of measuring, either quantitatively or in a crude qualitative fashion, the sequence of team behavior and then relating such information to team outcome. As mentioned by Connelly et al. (1980) team measurement should consider the fact that a specific task can have a unique effect on the total mission performance. The completion or incompletion of tasks, and the success or lack of success of tasks conducted throughout a mission can have varying cumulative effects on the mission outcome. There have been few attempts to assess these measurement issues.

WHAT FACTORS INFLUENCE TEAM PERFORMANCE?

Much small group research has been devoted to examining factors that presumably affect group output. There are fewer corresponding studies on military teams. The following factors will be examined in this section: performance feedback/evaluation, turnover in group membership, team coordination and cooperation requirements, group size, workload and workstructure or distribution, communication structure within the team, and group planning for the task. The influence of the type of task on performance has aleady been discussed and will not be discussed further here.

Performance Feedback

Since individual behavior is strongly affected by reinforcement and performance feedback, one might expect group or team behavior to be affected as well. This topic has not been neglected by team and small group researchers. However, within the team/group context the reinforcement contingencies are not as simple as they are within the individual situation. Several contingencies can exist, among them: (a) external reinforcement/feedback (e.g. feedback controlled by the experimenter or an evaluator) can be directed to the team as a whole (here some team members may be reinforced for inappropriate or wrong responses), (b) external reinforcement/feedback can be directed to both

individual members and the team as a whole, and (c) immediate feedback regarding the consequences of one's behavior may be received by individual members and/or the team as a whole during the conduct of the mission (such feedback can occur on either a regular or intermittent basis). The particular contingencies in existence during a team mission may be difficult to determine, and therefore the ability to predict behavior changes for individual team members or for the team as a whole may be more difficult than in individual reinforcement contexts where the reinforcement contingencies are less complicated.

Perhaps the most widely-cited studies in group reinforcement are those conducted by the American Institutes for Research (1962-1970). Throughout this series of studies teams were viewed as a single response unit whose behavior/output/performance could be modified by using procedures similar to those used to modify individual responses. All reinforcement was controlled by the experimenters, and the subjects performed a task where their actions did not provide intrinsic feedback. Various combinations of individual and group reinforcement, and nonreinforcement contingencies were systematically examined. The tasks performed required very little, if any, coordination among the group members, and group performance was limited to the sum of individual member performances.

Although the AIR researchers found that group performance in such contexts corresponded to that predicted from reinforcement principles, the contrast between such laboratory small-group tasks and military tasks is great. It would be inappropriate to assume that all the AIR conclusions would generalize to military situations since the contingencies within military training situations are quite different. For example, in the Klaus, Grant and Glaser (1965) study both individual and team reinforcement were given. This led to a more rapid development of team proficiency than team reinforcement alone, but the authors concluded that individual reinforcement had no positive carry-over effects and was functionally no more valuable than additional practice. One can seriously question whether individual reinforcement within military missions would have little carry-over effects. In another study by Klaus and Glaser (1965) teams composed of fast learners required more trials to reach criterion than teams composed of slow learners. This result was explained as a consequence of the lack of experience that fast-learning individuals had had with the low ratios of reinforcement characteristic of early team practice where only team reinforcement was given. However, within military training situations the presence of reinforcement/feedback contingencies other than those provided by training personnel or an evaluator would lead one to expect the opposite, that teams composed of fast learners would progress at a faster rate than teams composed of slow learners.

Similar laboratory studies have been conducted by Horrocks, Krug and Heerman (1960), Marra (1971), and Zajonc (1961). Limited degrees of teamwork were required by the tasks in these studies as well. Zajonc found that giving individuals direct feedback regarding their performance, the performance of other team members, and the group's

performance as a whole resulted in both higher group and individual performance than giving only group feedback. Marra also found that a double reinforcement condition (reinforcement to the individual and to the group) improved individual performance more than group reinforcement alone.

In a recent review of the effects of feedback on task group behavior, Nadler (1979) concluded that feedback to the group as a whole has an effect upon individual's attitudes toward the group (e.g., attraction) and influences task motivation (see also Berkowitz & Levy, 1956), while feedback to individuals within the group is more effective in directly influencing individual performance. Affiliation-oriented individuals prefer group feedback while task or achievement-oriented individuals respond to individual feedback.

Strange as it may seem, few studies have examined the impact of feedback/reinforcement within military teams, although many people (e.g., Briggs & Johnston, 1967; Hall & Rizzo, 1975; Wagner et al., 1977) regard it as critical to team performance. Briggs and Johnston elaborated upon the role of knowledge or results (KOR) and how KOR should be applied by instructors to achieve desired team performance. Their recommendations are the most specific guidelines regarding team feedback that exist in the literature at this date. Since these recommendations are cited later in this review, they are not repeated here (see also Section A of annotated bibliography). Not only is the team training situation complicated by the fact that more than one person can be reinforced, but also by such factors as the timing of feedback, its specificity, the power of the feedback source, and whether feedback is absolute or comparative in nature (Pritchard & Montagno, 1978). The complexity of team operations also makes it difficult to determine what should be reinforced at different stages of training. Although Briggs and Johnston's guidelines are important and should be considered in incorporating feedback within training programs, they are not complete.

Turnover in Group/Team Membership

Almost as sure as death and taxes is turnover in unit membership within the military. What effect does this have upon team performance? Forgays and Levy (1957) presented two opposing viewpoints regarding turnover: the individual-interchangeability concept assumes that individual specialists can be changed from unit to unit without any appreciable decrement in unit performance whereas the concept of crew integrity assumes a unit is a unique organization and will suffer in performance if membership changes occur.

Some studies of turbulance within military units have been conducted (Eaton & Neff, 1978; Forgays & Levy, 1957; Horrocks, Heerman & Krug, 1961; McDaniel & Dodd, 1972). The Eaton and Neff and the Forgays and Levy investigations were the most intensive. Forgays and Levy examined 95 medium-bomber crews during the last months of active conflict in Korea. Changes in crew membership over a ten-month period

were recorded. During this period, the number of crew changes ranged from 1 to 11, with the average per crew being 4.3. The officer positions of navigator, bombadier, and radar observer changed about the same number of times, approximately 30% more often than the typical enlisted-man position and about twice as often as the two pilot positions. Performance ratings and performance scores (e.g., circular error of bomb drops, time to arrive at mission control points) were available. Results showed the crews with four or fewer membership changes during this period performed better than crews with five or more changes.

Eaton and Neff examined turbulence within tank crews. They identified three types of crew turbulence: position turbulence (change in duty positions), personnel turbulence (any change in members assigned to a particular crew), and equipment turbulence (change in assignment to a particular tank). They expected crew turbulence to have its greatest effect upon crew members that interacted with each other, specifically the tank commander and the gunner. Four experimental conditions were compared which examined the effects of varying position, equipment, and personnel turbulence (see section C1 of annotated bibliography for details). The major finding was that position turbulence had the greatest effect in reducing crew performance in terms of hits and opening engagement times (i.e., the lowest performance occurred where the tank commanders were replaced by their gunners and gunner positions were filled by ammunition loaders). The authors felt that personnel turbulence might have had a greater impact if the crew tasks had been less structured.

In small group studies of turnover, researchers (Miller, 1971; Trow, 1964; Ziller, 1963) have hypothesized that changes in key or central team number positions will have the greatest effect upon team performance. This did occur in both the Trow and Ziller studies. In addition, Trow found that group performance declined when the replacement's level of intelligence was lower than his predecessor's. Morgan, Coates, Alluisi, and Kirby (1978) examined the relationship between the percentage of member turnover and team performance, and found that team performance declined when teams were composed of 40% or more untrained individuals.

Team Coordination and Cooperation

Few studies have investigated the impact of varying the form of coordination/cooperation required in team tasks. Banks, Hardy, Scott, and Jennings (1975) compared three military team configurations of various sensor systems (radar and night vision devices) to independent operations of such systems. They concluded that a team using the radar and night observation devices with proper coordination and employment procedures would obtain higher quality information than that provided by a single device or by two devices operating independently.

George, Hoak and Boutwell (1963) varied coordination among five-man laboratory teams by manipulating the extent to which members had to

respond for other members, the amount of feedback that members had to provide to others in order for the team to solve the problem, and the level of team task motivation that characterized the central man in the team. Higher performance occurred when the bulk of the team's strength was entrusted to three of the five members as opposed to only two members or distributed equally among all members. The authors concluded that when teams are formed the least competent individuals should be spread out among the teams, so no single team has more than its proportionate share. When the key man on the team was high on team task motivation, the team performed more effectively than when he was low. The authors speculated that coordinate behavior among team members becomes habitual in effective teams; that response coordination is learned by trial-and-error when team members are individually competent in their roles, and that it eventually becomes habitual when members are task-oriented because the resultant improvement in team performance is reinforcing to such persons. It is desirable to learn how to manipulate tasks and instructions so the coordinate response habit is established in team members early in their team history.

Some small group studies (Hewitt, O'Brien & Hornik, 1974; Kabanoff & O'Brien, 1979; O'Brien & Owens, 1969) have been based on O'Brien's (1968) distinction between collaboration tasks (members are expected to cooperate with each other at all stages of task activity as in discussion and problem-solving tasks) and coordination tasks (subtasks are allocated to different positions and the subtasks must be performed in sequence). With coordination, but not with collaboration, tasks group performance was related to the summed abilities of the group members. Task structure did create differences in group output, with collaboration structures often hindering performance.

Group/Team Size

Few studies of variation in military team size were found. Perhaps this is because in some teams the nature of the equipment determines the team size (e.g., a tank is designed to operate with four men), unit size is planned to correspond to the functions and responsibilities of the unit, and/or military personnel have relatively little flexibility in varying the size of units. One military team whose size has been investigated is the Infantry rifle squad. Havron and McGrath (1961) summarized a series of studies that examined four, five, six, seven, eight, and eleven man squads conducting tactical missions. In difficult tactical missions, squad leaders of the large unit maintained unit effectiveness at a great cost (e.g., higher activity level, more leader exposure to the enemy). The eleven-man squad with one leader controlling ten men was simply too large. With squads from four to eight men the six-man squad performed best. The present Infantry squad is formally designed with eleven men -- one squad leader and two team leaders with four men in each team.

Laboratory studies (Kidd, 1961; Kinkade & Kidd, 1959) have found that group productivity is not a linear function of group size (i.e., two-man teams are not twice as effective as a single individual, a

negatively accelerated function exists between performance and team size). This result is predicted from Steiner's (1966, 1972) process loss concept as well. However, none of the laboratory studies examined tasks that required more than one man (e.g., firing of a tank on the move). In such cases productivity should increase as individuals are added to the group until a point is reached where "superfluous" individuals are added and performance reaches a plateau. Given the limited manpower in most military units at the present time, perhaps the most important research question regarding team size is how small a team can be before its performance is significantly degraded.

Workload and Work Structure/Distribution

Many of the studies investigating the effects of workload on team performance have also examined different ways of structuring or distributing responsibilities within a team. In general, workload has been defined in the terms of the rate of stimulus or task input, as in simulated air traffic control teams where the number of incoming aircraft per unit of time was systematically varied (Johnston & Briggs, 1968; Kidd, 1961; Kidd & Hooper, 1959; Lanzetta & Roby, 1956b). In one study (Morgan et al., 1978) an entirely different operational definition was employed where load was defined as the percentage of untrained members in a team. On the other hand, there is little consistency across studies regarding the way in which work structure or distribution has been defined. For example, Johnston and Briggs, examined compensatory versus noncompensatory situations; Lanzetta and Roby (1956b) focused on specialization of team functions, and Roby and Lanzetta (1957b) compared the two conflicting organizational principles of autonomy and load balancing. The following discussion of workload and workstructure variables is organized by the type of team task.

Several studies have examined simulated air traffic control/intercept situations (Johnston & Briggs, 1968; Kidd, 1961; Kidd & Hooper, 1959; Lanzetta & Roby, 1956b). As one might expect as load increased, performance decreased. When Kidd varied air traffic control team size (one, two, or three men) as well as input load, he found that when input load was constant and team size increased, team performance increased moderately. In addition, when input load was increased proportionately to the increase in team size, performance was diminished in the multi-man teams. Kidd concluded that maximum performance can be attained when coordination demands are minimized in such tasks.

Load interacts with other factors as well. In Johnston and Brigg's study (1968), fewer flight errors occurred under high load conditions when a team member was allowed to compensate for his partner's behavior than when he could not compensate. Team communication disrupted performance of the noncompensatory teams under high load conditions, situations where there was the least need for and the least freedom to communicate. Lanzetta and Roby (1956b) investigated the effects of specialization of functions among team members in an air defense control center (three men). In the vertical structure (specialization of functions), each member was responsible for one function (observation,

calculation or decision-making) in all aircraft target areas. In the horizontal structure (nonspecialization of functions) each member was responsible for a single target area but had to employ all three functions. As pointed out by the authors this was a task that could not be peformed by one individual, in contrast to many other tasks used in small group research. Although structure effects did not occur, the authors stressed a tendency for the horizontal structure to be superior to the vertical structure under low load conditions.

Kidd and Hooper (1959) investigated three work structures in simulated two-man radar approach control teams. The authors attributed the superiority of the destination condition to the fact that it demanded less from team members; there were no team coordination requirements, only task demands. In that condition, aircraft bound for a particular landing field were always assigned to the same controller rather than assigned to different controllers.

Roby and Lanzetta examined work distribution on within aircraft/bomber crews. In most cases, the variations in work distribution affected the communication structure within the crew as well. In two studies (Lanzetta & Roby, 1956a; Roby & Lanzetta, 1957b) work load (rate of stimulus input) was varied, with high input rates resulting in an increase in crew errors. Roby and Lanzetta (1956b) elaborated on the effects of over-loads on individual behavior. An overloaded person was as likely to neglect obligations to other group members, thereby increasing their errors, as he was to neglect his own control responsibilities. Groups were unable to adapt fully to increased load. The burden of initiating communications was placed on the user of the information rather than the immediate source resulting in a loss of much relevant information. Similar results were found in ARIEM's (1978-1980) studies of continuous operations within Field Artillery fire direction centers.

The main thrust of these studies by Roby and Lanzetta, however, was to examine the impact of two conflicting organizational principles, autonomy versus load balancing. The autonomy principle states that the optimal arrangements of displays and controls in a man-machine system is one in which each person who needs certain types of information for making control actions is also the primary source of that information, and if information must be relayed to a control it should be relayed from a single source rather than from several sources. On the other hand, the load balancing principle states that the total work of the team should be distributed as evenly as possible. In studies (Lanzetta & Roby, 1956a; Roby & Lanzetta, 1957a) examining varying degrees of autonomy, situations which corresponded to the autonomy principle (members had direct access to most of the information they needed) were associated with fewer errors and faster learning times. The validity of both the autonomy and the load balancing principles was shown in one study (Roby & Lanzetta, 1957b). When autonomy was controlled, teams organized according to the load-balancing principles made fewer errors. When load-balancing was controlled, teams organized according to the autonomy principle made fewer errors.

In a very different context Moore (1961) found that easy access to needed information facilitated performance under high load conditions. Moore created two-man taxi-cab dispatching teams. One person had to assign cabs to passengers, the other to monitor the positions of the cabs, to start them on their runs, and to keep records. Contrary to the author's hypothesis, increased access to information (communication with each team member, observing electronic timers for each cab) enhanced performance in the high load (high rate or taxi requests) condition. The authors attributed this level of performance to effective and flexible load balancing procedures and "other acts of collaboration in performing routine functions . . . under free access to information teams were able to perform better early in the experimental session, minimizing waiting time without sacrificing accuracy, indicating a more rapid adoption of an effective team organization for getting work done" (p. 69-70).

Detection tasks were used in two studies. Morrissette, Hornseth and Shellar (1975) examined two two-man team conditions. In the redundancy condition each individual monitored all four displays, and in the division of labor condition each individual monitored two of the four displays. The redundancy team organization eliminated very long detection times, thereby reducing response variability. Three limited variations of military team structure were compared in a night detection study conducted by Banks et al. (1975). Three-man teams composed of radar operator, a night observation device operator, and a team chief operated as follows: when a detection was made with one device the operator communicated this information to the team chief who in turn interrupted the free search of the other operator, requesting him to verify the detection made by the first operator. The three team configurations all used this procedure and the structural variations involved primarily differences in physical location of team members. No performance differences occurred among these team variations, but comparison with individual operator performance data obtained in an earlier phase of the study indicated that the team configurations were better. The author stressed that the team chief's coordination role was particularly important for successful mission performance.

In summary, a consistent finding is that as team load increases and other factors such as team size remain constant, team performance decreases. Increased load negatively affects not only an individual's own responsibilities but also his responsibilities to other members which in turn reduces their performance. Work structure or distribution does affect team output. Researchers have stressed the need to create structures which reduce the demand for team member coordination. However, there are some indications that coordination demands do not necessarily have negative impacts when high degrees of accuracy are required, when efficient organizational arrangements are used, and when individuals are skilled in handling coordination demands.

Communication Structure

Much of the small group research on communication structures stems from Leavitt's (1951) work on communication nets, (e.g., star, chain, wheel). Guetzkow and Simon (1955) criticized Leavitt for not distinguishing between communication restrictions upon performance and organizational restrictions. When groups used the optimal organization pattern, different communication nets yielded similar performances. The authors noted, however, that certain communication nets created more organizational problems than others, thus lengthening the time to achieve efficient task performance. Lanzetta and Roby (1956a) also found that groups had difficulties in setting up an efficient system for detecting and communicating information changes. "Communication problems may result from ignorance on the part of response agents as to when information bearing on their controls enters the group at some other station, and on the part of information-source persons as to the relevance of new information they receive. Detection difficulties may be a function of a response conflict generated by placing the individual in the dual role of response agent and information source" (p. 313). Some of the studies cited in the previous section on workload and work structure stressed the importance of efficient communication to team performance.

George and Dudek (1978) examined the role of verbal communication during crew training. Results showed that performance was lower when verbal communication was limited in the early stages of training than when verbal communication was allowed, and that verbal communication facilitated learning the use of non-verbal cues.

Group Planning and Orientation

Group planning and orientation are commonly stressed functions within miliary units. The importance of these functions is supported by some small group studies. Hackman, Brousseau and Weiss (1976) compared three stategies which affected the manner in which a small group approached a task (assembly of small electrical components). One strategy instructed group members to discuss how they were going to accomplish the task; another strategy instructed members to immediately begin work and avoid discussion of the task; and the third strategy involved no instructions to the group (the control). Two task conditions were also investigated. In one condition every group member received the same information about the task; in the other, group members were given unequal information. As expected, based on previous work with small groups, little discussion of performance strategies occurred in the third group. Under the unequal task condition where the appropriate performance strategy was not immediately obvious, the discussion strategy resulted in higher performance than instructions to inhibit discussion. However, under the equal task condition where the appropriate performance strategy was obvious, instructions to inhibit discussion facilitated performance. Questionnaire results suggested that the discussion groups encountered more task and interpersonal problems than the other groups, but were more flexible. In light of

these results, one might hypothesize that discussion of mission strategy might be appropriate for some military team tasks (e.g., emergent tasks) but not for others (e.g., established tasks).

In another small group problem-solving study by Shure et al. (1962) a control group had no opportunity for discussion; a second group could plan only during the period of task completion; a third group planned between periods of task completion. Only the third group performed well. In the control group no stable communication structure occurred. In the second group where planning and task accomplishment occurred simultaneously, only a few groups established communication structures. Pressure to complete the task seemed more important than planning how to complete it. In the third group, a hierarchical communication structure was established rather early, and task performance paralleled the emergence and stability of this structure. These results have implications for military team training. Military personnel need to be reminded of the value of planning when pressure to complete a mission exists since they are apt to neglect it even though they know it is likely to improve team performance in the long-run.

WHAT HAS BEEN THE IMPACT OF MILITARY TRAINING PROGRAMS ON TEAM PROCESSES AND PERFORMANCE?

Of the variables examined in small group studies and simulations of military teams, performance feedback has been systematically incorporated into most military team training programs and has had positive effects (Alexander, Kepner & Tregoe, 1962; Findlay, Matyas & Rogge, 1955; George, 1967a; 1979; Havron et al., 1955; Root et al., 1979; ARI studies on REATRAIN 1976-1979). Feedback was provided in different ways in these programs, yet its importance in improving team performance and in changing team behavior and tactics during the conduct of an operation was stressed by all investigators.

Alexander et al. (1962) varied the amount of feedback Air Defense crews were provided in debriefing sessions. Those crews with feedback improved on practically every criterion compared to the stable performance of crews who did not get feedback. The authors found debriefing feedback particularly effective for Air Defense functions on which there was little information about the adequacy of performance during the mission itself, where the only way feedback could be obtained was through debriefing sessions. This result supports Briggs and Johnston's (1967) recommendation that KOR by instructors is particularly valuable in team tasks where there is little or no feedback intrinsic to the task itself.

Tactical studies of Infantry unit performance from the 1950s to the present have stressed the importance of feedback (George, 1967a; 1979; Havron et al., 1955; Root et al., 1979; ARI studies on REALTRAIN, 1976-1979). In fact the engagement simulation programs have been built around the principle of providing feedback, both during and after the conduct of a tactical operation. Development of procedures to provide realistic feedback during a mission has been stressed. The REALTRAIN

program is a good example of this. Use of telescopes to determine unique individual/vehicle number identification provides feedback regarding casualty assessment during the conduct of an operation. After action reviews by experienced training personnel provide additional feedback on tactical performance. The MILES (multiple integrated laser engagement simulation), which is presently being fielded within the Army but uses laser equipment for casualty assessment, is based upon the same feedback principles.

Another training variation in reinforcement, rather than feedback per se, is illustrated by Findlay et al. (1955). A weekly squad competition-reward program was established with squads participating in the program improving more on tactics and map reading tests than squads who were not in the reward program.

Another principle stressed in some training programs is that one "learns by doing" (George, 1967a, 1979; Root et al., 1979). For the military, this principle can be restated as "learning by doing in a combat-like environment." George's investigations show that if you want an Infantry squad to coordinate under the pressure of combat, then you must must train under similar conditions and emphasize the consequences of failure to coordinate. His program involved inserting events into tactical training missions that forced teamwork among squad members. Similar principles are illustrated in the Small Independent Forces (SIAF) materials developed by HumRRO (1970). The EFFTRAIN program (Root et al., 1979) focused on several ways of providing junior Infantry leaders with tactical training that essentially presented different ways of "doing": gameboard exercises, field exercises with leaders only, and REALTRAIN field exercises with troops. Conclusions reached by Shriver et al. (1979), that small unit leader training programs which involved only gameboard exercises did not provide adequate practice in leader/group interaction and communication and that field exercises are needed, support the principle of "learning by doing" in as realistic a situation as possible. However, they also noted that certain types of exercises (attack vs. defend) required more teamwork than others. Thus field training exercises may be more important in some contexts than others.

Despite the stress upon verbal communication in many small group and military simulation studies, there have been few military training programs that stressed member communication; its content, timing, frequency, etc. However, Siegel and Federman (1973) did train antisubmarine warfare helicopter crews on four communication content dimensions that had been shown to describe crew communication. Crews who received such training differed in both the absolute and relative frequency of these content dimensions. The trained group also performed better during a simulated tactical mission than the untrained group.

Havron's studies in the 1950s with Infantry squads illustrates one way in which a successful team training program can be developed. In the first phase of the work, three experimental programs were compared: the group participation method stressed maximum participation of each

squad member in the presentation and discussion of training materials in order to develop group loyalty and esprit de corps; in the fundamentals method all tactical training was structured around several basic combat principles which served as a frame of reference for all squad missions; the team training method stressed the duties of each member, employed a self-corrective system for performance of these duties, and used two teams within each squad to improve control and communication (the Infantry squad at that time did not have the present fire team structure). Based upon the tactical performance of squads trained in these three programs, a composite training program was developed which essentially combined the best of all three programs. It used all of the combat fundamentals training, major parts of the team training method, and very little of the group participation method.

The composite program was very successful. In fact, a most unusual result occurred --- there was no overlap in perforamnce between the composite trained squads and a comparison group on the Leadership group test. The authors attributed this strong difference to the fact that "mutual interdependence of men and the responsibility of all for squad performance" was emphasized throughout the training program. The men and the leader were encouraged to talk; to communicate. Procedures were developed so that individual members could integrate their individual task performance to the welfare of the entire unit. Thus when the leader was attrited, as often happens in combat, the remaining members were able to successfully continue the mission. A strong leader might not need to use such a "help" system, but he could. On the other hand, weaker leaders often profited from using such a system, thereby increasing the performance of the entire squad. It is important to note that these conclusions stressed the importance of team training, not necessarily individual proficiency, to mission success.

Two other types of military studies need to be mentioned. The BESRL studies of image interpretation (1965-1971) developed and tested the team consensus feedback method as a method for maintaining and enhancing the proficiency of individual image interpreters (individuals who must extract information from surveillance displays). On actual missions image interpreters work alone and are often unaware when they are doing a poor job. In team training, however, interpreters were forced continually to examine themselves, since their teammates found targets and made identifications that disagreed with their own. This awareness forced the team members to look hard at the target, and allowed less proficient interpreters to become aware of their deficiencies and to learn from the more proficient interpreters.

The USARIEM studies (1978-1980) on continuous operations in Field Artillery Fire Direction Centers (FDC) illustrate the complexity of team tasks and expand the number of variables that trainers need to include in military training programs. The studies also suggest that researchers may have only a minimal understanding of the factors affecting real-life team performance.

WHAT TRAINING RECOMMENDATIONS HAVE BEEN MADE FOR MILITARY TEAMS?

The following section highlights the major team training recommendations that have been made by experts in the field. A brief elaboration of each is also provided.

Team members should receive performance feedback. (Alexander et al., 1962; Biel et al., 1957; Briggs & Johnston, 1967; Caviness & Titus, 1977; Chapman et al., 1959; Findlay et al., 1955; ARI REALTRAIN studies, 1976-1979). Training situations that provide feedback during the exercise, as an automatic consequence of team and/or individual actions, as well as instructor feedback after the exercise are preferred. Some tasks have feedback mechanisms built into them; that is, team members can immediately observe the consequences of their actions. Other tasks do not provide such intrinsic feedback. Although feedback in the form of debriefings or after action reviews is important in both situations, it is particularly critical in the latter since that is the only feedback members receive. During initial training feedback by the instructor should not be too detailed or voluminous since individuals cannot absorb and may even misuse such information. At later stages of training, feedback should be more refined. Feedback must be provided on all important aspects of team functioning since individuals tend to maximize performance on those aspects about which they receive feedback. Individual feedback, rather than total team feedback, is particularly desirable in tasks where one man cannot compensate for teammates deficiencies.

Team training should be preceded by individual training (Daniels et al., 1972; Dyer, 1980; Finley et al., 1972; Johnston, 1966; Kress & McGuire, 1979; Schrenk et al., 1969; O'Brien et al., 1978). Some degree of individual proficiency is necessary for team training to be successful In addition, cross-training of team skills is not effective until individual expertise has been acquired. The relative emphasis given to each form of training depends on the team task, with tasks that demand little member coordination requiring less team training than those high on this dimension.

Team training should be sequenced in terms of increasing complexity and degrees of teamwork (Biel et al., 1957; Boguslaw & Porter, 1962; Caviness & Titus, 1977; Chapman et al., 1959; George, 1967a, 1979; HumRRO, 1970; Kress & McGuire, 1979; Thurmond & Kribs, 1978). The most complex form of team training involves situations that include emergent (unexpected, new) tasks. Cross-training can be used in team training to increase both individual and team proficiency.

The entire team should participate in team training (Biel et al., 1957; Chapman et al., 1959; Schrenk et al., 1969). The concept of the entire team includes officers who add leadership, stress, and motivation, and improve team cohesion.

Team training should be conducted periodically (Findlay et al., 1955; George, 1967a, Schrenk et al., 1969). Repetition of training will

increase long-term retention of skills. Periodic training should be conducted with different task/situations to enhance individual and team proficiency.

Military teams should be trained in conditions which approximate those situations in which they will be expected to perform (Briggs & Johnston, 1966a, 1967; George, 1967a, 1979; HumRRO, 1979; Jones & Odom, 1954; Kress & McGuire, 1979; Root et al., 1979; Shriver et al., 1979; ARI REALTRAIN studies, 1976-1979). If you expect a team to perform under stress, members must train under stress. If you expect a team to work as a coordinated unit, members must be trained under conditions that force teamwork. Teams find it easier to adapt to simpler conditions than to more complex, demanding conditions. The success of training programs such as REALTRAIN (which also included feedback) testifies to the importance of realistic training settings.

Team goals should be clarified (Biel et al., 1957; Caviness & Titus, 1977; Boguslaw & Porter, 1962; Chapman et al., 1959). Team goals should be spelled out in every way possible. Illustrations should be presented to show the consequences of errors to the team's performance.

Interdependencies among team members should be clarified (Boguslaw & Porter, 1962; Daniels et al., 1972; George, 1967a, 1979; Havron et al., 1955; HumRRO, 1970, Schrenk et al., 1969). Members of teams cannot and should not act independently of each other. Lack of coordination can often lead to serious team errors. The ways in which one member's actions impact upon another member or upon the team as a whole need to be illustrated and stressed.

Team training should include training individuals to analyze their own errors, to sense when the team or team members are overloaded, and to adjust their behavior when overloads occur (Boguslaw & Porter, 1962; George, 1979). In a team it is easy to blame someone else, the group as a whole, or a piece of equipment for one's own errors; but such actions are done at the expense of not learning how to avoid the error in the future. A team member needs to be able to sense when any member, including himself, is overloaded. Members should be taught how to adjust their behavior when overloads occur.

WHAT QUESTIONS AND METHODOLOGICAL ISSUES NEED TO BE EXAMINED IN ORDER TO IMPROVE TEAM TRAINING AND ASSIGNMENT?

Where should we go from here? Practically everyone who has examined the team area agrees that there is a lack of adequate theory, method, and systematic research, and that what is known about teams has not been applied to military training programs (Borgatta, Lanzetta, McGrath & Strodbeck, 1959; Collins, 1977; Hackman & Morris, 1975; Hall & Rizzo, 1975; McGrath & Altman, 1966; Meister, 1976; Wagner et al., 1977). Over twenty years ago, a task force on teams under the Director of Defense Research and Engineering (Borgatta et al., 1959) concluded that military support was critical to progress in these areas, since few

civilian agencies have a need to generalize to a variety of teams, focusing instead on problems related to human relations training.

Given the number of excellent state-of-art reviews that have been published within the last twenty-five years and the fact that progress has been limited during this period, it is doubtful whether this reviewer can suggest any new research areas or identify any new methodological needs. However, in this final section, the focus will be on research questions and related methodological issues which relate specifically to military team training and assessment.

What are the unique features of teams?

This question must be addressed from both conceptual and methodological viewpoints. Obviously, conceptual developments are central to theoretical work. Conceptual work at both molar and molecular levels is needed, followed by development of measurement procedures to objectively identify the existence of team characteristics (i.e., to distinguish teams from nonteams, and team tasks from group and individual tasks) and to quantify the strength of these characteristics (i.e., some teams may be characterized primarily by dimension A, others by dimension B). Such efforts are critical to the systematic investigation of other research questions and to the development of assessment procedures.

Some work in this area is presently being sponsored by the Army Research Institute. The work by Nieva et al. (1978) was an initial attempt to identify the basic dimensions that distinguish teams from collections of individuals (e.g., orientation, organization) in human factors terms, to identify team functions. Follow-up efforts in this area include validation of the team functions based on observation of Army team operations and the development of measurement instruments to identify and quantify each function. Another ongoing effort focuses on identifying and describing at a more molecular level the dependencies (e.g., verbal, nonverbal) among team members; dependencies conceptualized in such a way that they can applied to any team. In human factors terms, this analysis is at the task level. Procedures for recording and describing such dependencies are being developed. This work is based on observations of a variety of Army teams. Future efforts will focus on relating team functions to team tasks/dependencies in that functions are inferred from dependencies. This final effort should yield procedures, at both conceptual and methodological levels, for defining the nature of "teamwork."

How do teams develop?

A training program needs to be based on a concept of what characterizes a good team and what stages, if any, a team goes through in its development. Are there Piagetian-like stages of team development; some aspects that you cannot rush no matter what the training? What team skills are susceptible to training? Do teams

progress through the same phases of development irrespective of group and individual learning rates or the team tasks? How do interpersonal perceptions and expectancies change with experience and how do these changes affect team peformance?

Longitudinal studies of teams are needed in order to address such developmental questions. Since team development may vary with the type of team and the team task, such variations should be examined. Teams need to be exposed to routine tasks, unexpected tasks, new tasks, and stressful, demanding tasks in order to examine the full range of team behavior and development. Procedures that record sequences of interaction, rather than simply summarize frequencies or rates of interaction, are needed so that such sequences can be related to task goals and strategies. Such procedures may be particularly important for describing phases of team development and the distinguishing features of good and poor teams.

What are the characteristics of good teams and how do these characteristics relate to training criteria?

Although teams may continue to evolve with time and experience, there comes a point when individuals can identify a good team when they see one. What are the characteristics of such teams? Are these the criteria to which we train? Is observation the only way of identifying such criteria; is it the best way; or can such criteria also be determined by applying human factors/systems approaches? Do excellent teams exhibit characteristics that cannot be or are not frequently derived from system analysis techniques? Are "good" teams identical or is there more than one way of being "good?" Obviously, if alternatives exist, multiple criteria should also exist. In judging a team, what is an appropriate balance between process and product criteria? Within each of these domains are certain criteria more important for some teams and/or team tasks than others (e.g., product criteria - time versus accuracy)? What is the best way to make these determinations?

Since we do not have the answers to such questions, researchers should continue to use a variety of approaches to identify the characteristics of good teams. Application of a single approach may be too narrow. Strategies for identifying team criteria need to be developed. Improvements also need to be made in the criterion measures themselves, both process and product. We must always be aware of the tendencies to measure what is easy to measure and to overuse a technique once it has been developed, neglecting work on other needed techniques.

What variables influence team behavior?

The list of variables that could impact upon team performance could be endless. However, previous research in this area points to some areas that need to be explored further, and the nature of the military training environment indicates other variables. The influence of such variables on team processes, team output, and the interaction between

team processes and products needs to be examined. It is also important to know which factors are under a trainer's control and which are not.

Research indicates that team behavior is influenced by feedback. Briggs and Johnston (1967) made many recommendations regarding the application of feedback, but there have been no systematic studies on the effects of such procedures using military teams nor on the ease with which such procedures can be implemented within the military training environment. Other unresolved issues include the appropriate balance between individual and group feedback, the specificity and detail of feedback, how to train trainers to give appropriate feedback, and how to design training environments that provide more complete feedback.

Team load affects team performance. With military teams, load is a critical issue. In combat, teams are under considerable stress and pressure, and may be forced to operate for long periods of time. Much more information is needed on how these factors influence team behavior and interact with team experience/skill, and how one can best train and organize a team for such situations.

A continuing problem within Army units is turnover in personnel. Certain types and degrees of turnover have been shown to produce decrements in team performance. Yet there are still unanswered questions regarding turnover. Are some types of teams less affected by turbulance than others and why? What are the best procedures for integrating a new individual(s) into a team?

The issue of team size has been extensively studied in the small group literature with the focus being upon whether or not team output is a linear function of team size. However, given the reality of combat attrition and the present military manpower shortages, the critical question is how small a team can become before its performance is significantly degraded. Can teams be reorganized or restructured to minimize the effect of size reductions? Can cross-training reduce the impact of reduction in size? At what point is the team size so small that the team essentially ceases to exist?

Studies indicate that individual proficiency is needed before unit/team training can be effective. But there is little research on how much individual training is needed and on strategies for analytically determining the desired amount of individual training. Does the amount of individual training vary with the nature of the team or team task, with the complexity of individual and team skills, etc.? Is the best training sequence simply individual training followed by team training, or is there some point in team training where it is important to initiate a more complex and demanding individual-team training cycle? What individual skills are learned during team training? What individual skills cannot be learned during team training? A related issue is the extent to which higher-echelon training at the company and battalion level provides team (squad-level) training.

There is substantial research on the retention of individual skills. However, little is known about the rates with which different types of team skills decay and the frequency with which refresher training should be given.

Although military leadership questions were outside the scope of this bibliography, this area should not be ignored in team research efforts. In particular, it is important to know whether a good leader's performance can compensate for a poor team. Are there some situations in which compensation is impossible or very limited and therefore team training becomes particularly critical? On the other hand, it is also useful to know the extent to which a good team can compensate for a poor leader.

What team skills should be trained?

Team training requirements should be based on such factors as an analysis of skills required for team mission success, skills that have been demonstrated to affect team success, skills that are not trained in higher-echelon exercises, team skills that are not learned easily, skills that do not develop automatically when a team is formed or as a simple function of mission repetition, skills that decay quickly, and skills that are performed infrequently but are essential to team survival (e.g., aircraft emergency procedures). Analytic techniques need to be developed to answer some of these issues; further research is needed to address others. Research without analysis or analysis without research would be inappropriate and might lead to inadequate training programs.

How should team training programs be designed and evaluated?

Once team training requirements have been determined, the factors that affect team performance identified, and team behaviors that are immune to manipulation identified, the design of team training programs can begin. Training resources such as equipment, time, training ranges, other training media, and instructor personnel; the skills and abilities of the team members being trained; and the interaction between member skills and training media/resources must be considered. For example, in one study (Bialek, Taylor & Hauke, 1973) techniques successful with high aptitude soldiers failed with low aptitude soldiers. In particular, with high aptitude individuals, minimal guidance was required, self-instructional booklets could be used, fewer practice problems and examples were necessary, and instructors acted primarily as class monitors. Such individuals also created much peer pressure among themselves to do well; pressure that was not characteristic of low aptitude individuals. Low aptitiude individuals performed better with instructional procedures that maximized personal interaction with the instructor.

Instructional techniques that are most effective for training different skills should be determined. It is highly unlikely that one procedure can satisfy all training requirements for a particular team.

Such judgments may be made on an analytic basis, upon experimental data, and/or upon the resources available. Techniques for integrating information from these various sources should be developed. Frequently, only one of these factors is strongly considered. Havron's (Havron et al., 1955) final training program for Infantry squads was based on experimental data; apparently there were few resource constraints. In the development of training programs for new military equipment, front-end analytic techniques are used heavily. In active Army units, resources may be the overriding factor.

Finally, the effectiveness of training programs must be determined. Given the limited body of knowledge regarding what contributes to effective team training it is unwise to develop and evaluate a single program for a military team -- to put all your eggs in one basket. Much can be learned from comparing different training programs which will eventually contribute to a much better training program. It is particularly important to evaluate such programs with different samples of teams and under different environmental conditions (e.g., simulated combat conditions vs. garrison). Since such tests can be costly, they should be conducted with great care and should not be initiated until the researcher has good assurance that the assessment can be conducted properly.

In assessing team training effectiveness, training criteria and training standards for success on those criteria must be employed. These criteria should focus on dimensions unique to teams. The issue of measuring team skills was mentioned earlier in this final section, and throughout this final discussion it was assumed that measures of team skills (process and product) existed. However, few such tools do exist and their actual construction is not easy. The importance of developing reliable and valid measures which cover the spectrum of team skills should not be minmized. It would be unfortunate if the knowledge gained and decisions made during each of the research stages just described were to be "bad" ones because of inadequate or inappropriate measures of team skills.

ANNOTATED BIBLIOGRAPHY OF TEAM RESEARCH

The bibliographic entries have been categorized by the sections cited in the table of contents. Within each section, the studies have been alphabetized by author, except where a series of related studies has been conducted within the same organization or by the same individuals. Such related studies are grouped together at the end of each section. The entries vary in length. When the methods and/or results of a study were particularly relevant to Army teams, this information was described in some detail. Some articles are cited in more than one section of the bibliography. The first reference of the article provides the complete summary. When the article is cited again, a cross reference to the original citation and a brief description are given. An alphabetical listing of all references is presented at the end of the report. This reference list also indexes both the appropriate section(s) and page(s) of the bibliography for each study.

A. LITERATURE REVIEWS AND/OR MODELS EXAMINING EFFECTS OF VARIABLES ON TEAM PERFORMANCE

Section A contains reviews of small group/team research that have been published within the last twenty years. Some were oriented toward military teams, others were not. The classification below presents the major emphasis(ses) of each review.

1. Team Training

Alexander & Cooperband (1965)
Boguslaw & Porter (1962)
Briggs & Johnston (1967)
Crawford (1964)
Collins (1977)
Daniels et al. (1972)
Denson (1981)
Hood et al. (1960)
Turner, Cohen & Greenberg (1981)
Wagner et al. (1977)

2. Team Functioning/Behavior/Processes

Alexander & Cooperband (1965)
Boguslaw & Porter (1962)
Hackman (1979)
Haines (1965)
Hood et al. (1960)
Knerr, Nadler & Berger (1980)
Steiner (1972)

3. Factors affecting Team Performance

Briggs & Johnston (1967)
Denson (1981)
Gagne (1962)
George (1962)
Geo. Wash. Univ. Med. Cntr. (1974)
Gill (1977)
Hackman (1979)
Heslin (1964)
Honigfeld (1965)
Knerr, Berger & Popelka (1980)
Berger, Knerr & Popelka (1979)
Meister (1976)
Nadler (1979)
Sells (1962)

4. Small Group Research

Altman (1966)
Collins (1977)
Lorge et al. (1958)
McGrath & Altman (1966)
Nieva, Fleishman & Rieck (1978)

5. Communication

Briggs & Johnston (1967)
Glanzer & Glaser (1961)

6. Lessons from Combat Experience

Greenbaum (1979)

Alexander, L.T. & Cooperband, A.S. System training and research in team behavior (TM-2581). Santa Monica, Calif.: System Development Corporation, August 1965. (DTIC No. AD 620 606)

A review on team training as it applied to air defense training of computerized command/control systems was presented. However, most of the literature reviewed related to team training in general as well. A research program designed to address research gaps in team training was outlined.

The authors stated that computerized command/control training systems should achieve the following training objectives: increase the capability of system personnel to respond adequately to unusual environmental situations, develop and maintain personnel skills in applying existing rules, and train personnel to operate effectively as a team. Three major sources of training problems associated with such systems are specification of training objectives, effective use of training media and techniques, and evaluation of training progress.

The authors presented and contrasted two theories about the characteristics of teams and how teams learn, called the organismic and the stimulus-response views of a team. They suggested that the stimulus-response model applies to teams operating in established situations, while the organismic model applies to teams operating in emergent or changing situations.

A review of previous research on team training focused on three classes of variables: input or task environment variables (specifically, load), knowledge of results (intrinsic and extrinsic KOR; team and individual KOR), and exercising or practice (scheduling of practice, team and individual practice).

A model of team behavior in emergent situations was presented. "The team is an information processing system which has a large storage capacity, part of which is devoted to procedures for action that are organized hierarchically into plans which coordinate the behavior of the individual members. These plans may be given to the team... or they may be generated by the team itself. ... The task situation determines which plan(s) will be utilized. The performance of the team depends on how good the plans are and how well they are executed. As a result of continuing experience with the environment, the team generates and tests new plans and adopts some of them.... This entire process may be considered as a two-level learning process: learning the characteristics of the environment and learning new methods for responding to it. To the extent that what is learned at either of these levels can be transferred to new and indeterminate situations, team performance will improve" (p. 33).

Altman, I. The small group field: Implications for research on behavior in organizations. In R.V. Bowers (Ed.) Studies on Behavior in Organizations. Research Symposium. Athens, Ga.: University of Georgia Press, 1966, pp 64-86. (DTIC No. AD 647 001)

A system for classifying the results of small group research, developed by Altman and McGrath, was summarized. General statements were made regarding the effects of such factors as the environment, group characteristics, and individuals' personalities upon the effectiveness of the group. Deficiencies in the measurement of performance effectiveness were also cited.

Boguslaw, R., & Porter, E.H. Team functions and training. In R.M. Gagne (Ed.), Psychological principles in systems development. New York: Holt Rinehart & Winston, 1962, pp. 387-416.

Boguslaw and Porter's paper focused upon the meaning of the concept of team, the meaning of team functions for both established and emergent team situations, and team training technologies. A team was defined as a "relationship in which people generate and use work procedures to make possible their interactions with machines, machine procedures, and other people in the pursuit of system objectives" (p. 388). Team functions were viewed as specific purposes which contribute to the attainment of the team's objectives. Unless team functions are clearly understood, system performance cannot be adequately evaluated and training of team members is apt to be unduly unrestricted. Team training was defined as "any experience in which a team engages which results in a change of team function, team organization, or team performance" (p. 391). The authors stated that a serious shortcoming in traditional team training efforts is the acceptance of work procedures, machine procedures, and machines as givens. This leads to defining training problems solely in terms of increasing crew/team proficiency in the fixed procedures (that is, component training) rather team training, since the interaction among components of the team is ignored.

Emergent and established situations were distinguished from each other. Any team may deal with situations that vary from established to emergent. Generally speaking, functions for established situations are formally planned for in the design of a system, while emergent situations are more likely to be ignored on the formal level. Various approaches to formulating established functions were presented. Five methods for dealing with emergent situations were cited: selection and use of a good manager, selection and use of equipment and facilities, formulation of policy guides, improvement of systems analysis and computer technologies, and team training.

Team training for established or emergent situations should consider factors other than training each man in his individual job. At least six other factors should be considered: orientation to team goals, training in interdependencies, training for error analysis, training for sensing overload, training in adjustment mechanisms, and training for emergent situations.

Much prior team research has focused on established functions of teams. A disadvantage with such a simplified approach is the possible loss of significant variables. In particular, "where total systems are subject to stress by overload or by sudden degradations, representations of established functions do little to help the researchers develop concepts for training teams to meet these overloads and stresses." (p. 413).

Briggs, G. E., & Johnston, W. A. Team training (Technical Report: NAVTRADEVCEN 1327-4). Columbus, Ohio: Ohio State University Human Performance Center, June 1967. (DTIC No. AD 660 019)

This document is the final technical report on a series of studies of Navy Combat Information Center (CIC) team training. The report summarized the last year of research which focused on such factors as workload (specifically, time stress), team arrangement (variations in responsibilities assigned to team members), content of team communication, selective reinforcement of team communications, and effects of communication reinforcement in transfer situations.

An excellent technical review and discussion of team training research was also presented. Three areas were examined: team structure/task organization, training variables, and communication variables. The authors' conclusions and recommendations (p. 45-49) regarding each of these areas are presented in their entirety in the paragraphs that follow.

Team Structure and Task Organization

1. A hierarchical structure for team organization is desirable for several reasons:

   a. It is more reliable than a decentralized structure.

   b. Less total training time is required for personnel since each man need not learn all jobs.

   c. It permits an open communication system during periods requiring all team members to provide data and opinions so as to reduce input uncertainty and formulate possible courses of action. Moreover, once a course of action has been selected, it permits "leadership control" over the communication system so as to restrict verbal interactions to the specific job of carrying out a course of action.

2. Parallel substructures within a hierarchical structure are preferred to serial structures for several reasons:

   a. In a serial structure team performance is more dependent on the least skilled team member than is the case in a parallel structure.

b. Load balancing is more easily carried out in a parallel team structure although care must be exercised in such load-balancing attempts: one should avoid increasing interoperator interaction requirements.

3. Superior team performance may be expected in teams organized such that minimal interaction between team members is required for each man to do his job. Independence of assigned function permits each operator to utilize his entire information-processing capacity to his specific job; if required to interact with other team members at either the input or output level, an operator must share that capacity between specific demands of his job and the demands of the interaction process. Unfortunately, despite highly overlearned verbal behavior, teams appear to require extensive experience before they learn efficient verbal interaction procedures or before they acquire interaction discipline.

4. Teams can learn to adapt to an increase in load on the system provided the operating procedures permit such flexibility. Apparently, they do this by reassignment of function, the utilization of short-cuts, the development of new procedures, etc. However, flexibility in operating procedures is a mixed blessing in that there are unusual circumstances, such as emergencies, when more rigid rules result in better overall performance.

Training Variables

1. Adequate debriefing sessions following team training sessions are an invaluable opportunity for the team to examine not only individual proficiencies but to explore alternative ways of organizing the task so as to develop more efficient and proficient team performance. The instructor would do well in such debriefing sessions to provide adequate time for discussions. Too often, a debriefing during training is made to fit the time available before the students rush off to the next class or assignment. This is a mistake, especially for relatively large teams in complex systems.

2. The debriefing periods provide the instructor with his main opportunity to deliver knowledge of results (KOR) regarding the preceding team performance. KOR is a powerful tool in both training and operational contexts, and several conclusions appear in the literature regarding its effects on team performance:

a. KOR is particularly valuable in shaping behavior in those team tasks for which there is relatively little feedback intrinsic in the task itself. However, care must be exercised during training so that students do not become overly dependent on KOR which will not be present in operational tasks.

b. The use of individual-specific KOR (rather than total team KOR) is desirable especially in team tasks where it is not possible for one man to compensate for the deficiencies of his teammate(s). This is

especially true for relatively high-ability team members; however, low-ability team members can benefit equally from individual-specific or from total team KOR.

c. The specificity, detail, and quantity of KOR must be controlled rather carefully by the instructor. During initial training relatively gross aspects of individual performance are satisfactory and more detailed KOR simply cannot be used by the team members; indeed, they may misuse such information. During later stages of training detailed and more voluminous KOR may become invaluable for the "fine tuning" adjustments of highly skilled teams.

d. Teams will attempt to maximize those aspects of performance about which they receive specific and simple KOR even though other aspects of team performance may suffer in the process. In other words, teams will "do as they are told" by the instructor via KOR. Therefore, if several aspects of team performance are equally important, care must be exercised not to emphasize one to the detriment of the other aspects.

e. If teams experience a change in specific and simple KOR they will readjust their performance rather rapidly to emphasize that aspect of performance about which they now are receiving KOR, even though this results in a deterioration of that aspect previously emphasized by KOR. However, if teams experience a change from specific and simple to more complex KOR (where two or more aspects of performance are given an equal weight), then they will continue to emphasize that aspect of team performance which previously was the subject of specific KOR while at the same time attempting to improve all aspects now being emphasized. Thus, an instructor must expect some conservatism in team performance as the complexity of KOR is increased, i.e., a team will "cling" to the more simple past as the complexity of the present KOR makes it more difficult for them to satisfy instructor demands.

3. Direct evidence for the superiority of team training over individual training does not exist. Indeed, laboratory research indicates that team performance is superior following individual training in systems organized for relatively little interaction between team members; and in systems organized for a fairly high degree of interoperator interaction (coordination) both laboratory and field research indicate that individual and team training procedures produce fairly comparable team performance. This is not to deny the use of team training; rather, it indicates that individual training deserves emphasis even in so-called team training simulators. It would appear that true team training is best conducted either "on the (operational) job" or in final transition training with operational equipment.

4. Operator replacement in a team can have a temporary deleterious effect on team performance especially if the replacement is less skilled than the man replaced. However, sufficiently well trained replacements may have little or no such effects. The team can adapt rather quickly even to a replacement with

less skill than the man replaced through load balancing and other adjustments within the team.

Communication Variables

1. Intrateam interactions involving verbal communications are an index to the level of team coordination present. However, care should be exercised by instructors in using the more obvious aspects of verbal communications (such as sheer volume) as evidence for the acquisition of team coordination. More subtle aspects of communication, such as the presence of voluntary messages which anticipate information needs of other teammates, may be more directly correlated with objective measures of team coordination.

2. With training, teams exhibit progressively less volume of communications and the pattern of these messages changes as a function of both training and task variables:

a. There appear to be four general characteristics of communications between team members:

(1) One class of messages represents attempts by teams to reduce input uncertainty.

(2) Given some amassing of input data, a second class of messages represents attempts to evaluate what is "known," a step necessary to the formulation of hypotheses or alternative courses of action.

(3) Following data evaluation, a class of messages occurs dealing with possible courses of action.

(4) As a single course of action is decided upon, leadership control messages (commands) occur as the course of action is implemented.

b. Leadership control results in a discipline on the team in their communications. This is a necessary aspect of operational systems, and disciplined communications are desirable in the training context also. However, in the latter, the instructor should be alert to avoid premature leadership control which can stifle necessary intrateam communications, i.e., the trainee "commander" should not assume control too early in a problem run.

c. Time stress on a team will result in fewer communications than when they are required to accomplish less per unit time. Further, under time stress the pattern of team communications will involve more objective information messages than tactical, evaluative, or opinion-type messages. Just the opposite occurs when teams work under low time stress and when they are encouraged to develop highly coordinated performance. It follows that time stress fosters communication discipline. Whereas teams will maintain such discipline when experiencing a change from high to low time stress,

the opposite does not occur, i.e., the more free and relaxed interaction among team members which is possible under low time stress persists when time stress is increased. Therefore, instructors should attempt to encourage greater self-discipline and leadership control by the team members as they experience significant increases in time stress during and between training problems.

d. The availability of information channels in a system markedly influences the content of team communications. Team members can utilize the less efficient verbal communication channel to transmit objective information when machine channels (such as the radar display) suffer partial failure. However, such transmissions can occur in such volume, especially in less capable teams, so as to exclude other necessary types of messages. It appears, particularly in less skilled teams, that the transmission of objective data becomes an end in and of itself to the exclusion of messages necessary to utilize these data.

e. One can control the volume and content of communications between team members by the use of immediate feedback which reinforces one type and "punishes" another. Therefore, again, the instructor has a potent tool to shape team behavior. However, such feedback can produce unusual effects on performance and no clear conclusion appears as yet on the use of specific training for verbal communications. It is apparent that the acquisition of communication skill is a rather lengthy process despite the tremendous overlearning present in this response mode.

f. In general, laboratory research on team communications indicates that the less such interoperator interaction, the better.

Crawford, M.P. A review of recent research and development on military leadership, command, and team function (HumRRO Research Memorandum). Alexandria, Va.: Human Resources Research Office, The George Washington University, September 1964. (DTIC No. AD 478 288)

A brief review of team training studies conducted in the early 1960s was presented, including work on air-direction centers, aircraft crews, Infantry squads, and tank platoons.

Collins, J.J. A study of potential contributions of small group behavior research to team training technology development. Alexandria, Va.: Essex Corporation, August 1977. (DTIC No. AD A043 911)

The purpose of the review was to identify scientific and technical advances applicable to the development of an improved team training technology. Team training research and small group research were both reviewed for theoretical and methodological developments and for substantive findings. The author concluded that team training technology is underdeveloped and that few advances have been made within the past ten years because of limited research and development funding. Some of the specific deficiencies found were: absence of a theory of team behavior; lack of

population data on teams; limited analytical techniques and criteria for the study of teams, their training, and their performance; few assessment, evaluation, and feedback systems for use by operational military units during team training; lack of an instructional system development (ISD) model for teams; and absence of team training guidelines for use in the design of large, complex team training devices.

Daniels, R.W., Alden, D.G., Kanarick, A.F., Gray, T.H., & Feuge, R.L. <u>Automated operator instruction in team tactics</u> (NAVTRADEVCEN 70-C-0310-1). St. Paul, Minn.: Honeywell, January 1972. (NTIS No. AD 736 970)

The purposes of the study were to determine if a generalized approach to team training was feasible, to recommend training procedures if a generalized approach was appropriate, and to recommend other approaches that could increase team training effectiveness. Three Navy training devices were selected for examination. Tasks performed on each device were analyzed in terms of a task taxonomy, which divided the task into stimulus, cognition, and response elements. These elements were further divided as follows:

Stimulus modality (none, visual, aural, touch, combination, other)

Stimulus information uncertainty (noise; simple, one-bit, no uncertainty; simple, single-parameter, discrete; simple multiparameter, discrete; complex, multiparameter, discrete, continuous complex, multiparameter, continuous; complex parameter)

Perception (unidentified, detection, discrimination, recognition, identification, classification)

Information processing (data analysis, problem diagnosis, concept formation, innovation/creation)

Action selection (no action, seek information, follow specific rule, follow general rule)

Response modality (none, visual orienting, verbal, motor, combination, other)

Response complexity (simple discrete; controlled, single parameter, discrete; controlled, multiparameter, discrete; complex, skilled, continuous; compound, multiparameter, continuous; high skill, fine control)

This classification procedure did not describe task sequence interactions nor the specific content/nature of the task.

The authors concluded that a generalized approach to team training was not feasible. Task elements common to all of the team members were at a relatively low level, involving little uncertainty and low complexity. The analysis did indicate, however, that there was some commonality among specific subsets of team members (e.g., tasks involving high uncertainty were common to the decision-makers and sensor operators).

A short review of current Navy tactical team training was also presented. The authors found that team training was not reaching its required or potential effectiveness for the following reasons: intact teams seldom appeared for training on team training devices, individual team members often lacked the prerequisite skills for the training of team tactics, and instructor personnel were not adequately prepared for their jobs as instructors.

General techniques recommended to improve training were performance feedback, development of training software (e.g., specify training objectives, performance criteria, evaluation tests), and application of advanced technology to team training (e.g., video-tape lecture, split screens comparing good with poor performance, use of computer to continuously collect and analyze performance data, computer simulation of other team members).

A general sequence of individual and tactical team training was proposed. Individual skill training should be first, followed by training with an assembled team to stress interaction, coordination, and development of a sense of team awareness, with tactical team training that deals with uncertain, ambiguous or emergency situations being the last stage.

Six steps in designing an effective training system were outlined: task and function analysis, training requirements analysis, training program development, training device design, training program and evaluation, and training program revision.

Denson, R. W. Team training: Literature review and annotated bibliography (AFHRL-TR-80-40). Wright Patterson Air Force Base, Ohio: Logistics and Technical Training Division, Air Force Human Resources Laboratory, May 1981.

The review concentrated on team research conducted after 1960. The following areas were covered in the review: team definition, nature of team training, effects of individual characteristics on team performance, characteristics of tasks performed by teams (established vs. emergent, load), team characteristics (cooperation, coordination, communication, size, composition), impact of various types of feedback on team and individual performance, measurement of team performance, and the applicability of instructional systems development to the team process.

Gagne', R.M. Military training and principles of learning. American Psychologist, 1962, 17, 83-91.

Gagne' discussed the applicability of laboratory principles of learning to military training situations. The military situations discussed were individual tasks rather than team tasks; in particular, aircraft gunnery, putting a radar set in operation, and finding malfunctions in complex equipment.

If a psychologist were asked what principles of learning could be applied to improve training of such skills, he might cite such principles as the following: the best way to learn a performance is to practice it, learning will be more rapid the greater the amount of reinforcement given during practice, principles of distribution of practice, and distinctiveness of elements. Gagne' illustrated how many of these principles are not the most relevant for some military tasks. For example, in learning how to operate a radar set, the motor tasks (setting switches and dials) have already been learned. What is required is the learning of procedures, and the best way to accomplish this is to provide the learner with a list that gives the required sequence of events. The learning of the list contributes the most to the task performance, not the practice of the radar switching responses. Gagne' concluded that techniques of task analysis, the principles of component task achievement, intratask transfer, and the sequencing of subtask learning will be more useful in the design of military training than well-known learning principles such as reinforcement, distribution of practice, and response familiarity.

George, C.E. Some determinants of small-group effectiveness. (HumRRO Research Memorandum No. 26). Ft. Benning, Ga.: U.S. Army Infantry Human Research Unit, May 1962 (rev. October 1962). (DTIC No. AD 628 204)

George reviewed studies (including military literature) published between 1955 and 1962 on small group effectiveness in resolving complex and difficult problems. The primary focus was upon the following motivational and social dimensions of groups and group members: general intelligence and role competence, social intelligence, information flow, small group codes (common opinions held by group members), stress in small groups, social power, power structure, and informal group structure associated with cohesion, conformity, personality, group size and newcomers to the group. In the final chapter a mini-theory of an efficient group was presented along with implications for military research. Some of the research ideas were tested in a later series of studies by George (1963).

Several of the topics reviewed may be relevant to work on team performance dimensions and/or indirectly affect the effectiveness of teams performing certain tasks and therefore should be considered in such analytic efforts.

George concluded that group effectiveness was facilitated when group members were able to anticipate the needs of group members and to predict each other's response to pressure and fatigue (called interpersonal knowledge). The implication was that groups with relatively insightful people tend to

become task oriented since group members are not tied up with interpersonal problems.

Based on Bass's work, George distinguished between three types of group codes held by group members: self-oriented (motivated by a need to achieve prominence within a group even at the expense of group goals), interaction-oriented (motivated by being in a harmonious relationship with other members to resolve internal problems rather than external tasks), and task-oriented (reinforced by satisfactory discharge of group tasks). However, at the time, no good measurement procedures had been developed for quantifying group codes. Some measurement suggestions were given.

George concluded that no simple statement could be made regarding the effect of group size, but that the effect of size depended upon the kind of group, task difficulty, group's prior history, the complexity of the group structure, and the characteristics of the group leader.

Military literature on turnover in group membership seemed to indicate that assimilation of a newcomer is faster when the group is under stress than when it is not under stress. Laboratory studies indicated that the rate of assimilation increases if the group expects a new member and if the newcomer brings information and skills to the group.

Note. - These dimensions provide objective means of describing intra-team communication and of distinguishing among teams. However, the basic data necessary for calculating these indices may be difficult to obtain, particularly when team activities occur at a fast pace.

George Washington University Medical Center. Studies of social group dynamics under isolated conditions: Objective summary of the literature as it relates to potential problems of long duration space flight (NASA CR-2496). Washington, D.C.: Author, December 1974. (NTIS No. N75-15308).

Research dealing with the study of human behavior and crew interaction in situations simulating long term space flight as of May 1974 were reviewed. Environments examined in the studies included the Antarctic, the Arctic, laboratory settings, fall-out shelters, submarines, space flight simulation, and underwater habitats. Examples of the variables examined in these research environments included crew size, length of confinement, group dynamics, individual dynamics, emotional symptoms, cognitive functions, psychomotor functions, motivation, performance, and self-ratings.

Gill, D.L. Cohesiveness and performance in sport groups. In R. S. Yeeton (Ed.), Exercise and sports sciences review (Vol. 5.). Santa Barbara, Calif.: Journal Publishing Affiliates, 1977.

Gill reviewed studies examining the relationship between cohesiveness and performance within group sports, finding inconsistent results. One of the difficulties with research in this area is the lack of a conceptual framework for the concept of cohesiveness and the resultant measurement problems. A distinction was drawn between social cohesion and task cohesion; a distinction

that may be relevant to military teams as well as to group sports. Recently, some researchers have examined the nature of the causal relationship between cohesion and performance with path-analytic techniques. In general, despite some methodological problems, the data support the assumption that the predominant causal direction is from performance to cohesion, rather then vice versa. Other investigators have suggested that the cohesiveness performance relationship is circular, rather than linear, although no direct tests of this hypothesis have been made. Variables which may influence the cohesiveness-performance relationship are goal-path clarity for task-oriented groups, value similarity among group members for informal social groups, and task characteristics.

Glanzer, M. & Glaser, R. Techniques for the study of group structure and behavior II. Empirical studies of the effects of structure in small groups. Psychological Bulletin, 1961, 58, 1-27. (DTIC No. AD 254 918)

Glanzer and Glaser reviewed experimental laboratory studies that examined the effect of different communication structures upon small group performance. Generally, these groups were of five members or less. The initial work in this area originated from questions posed by Bavelas in 1948: "what effect does the structure of the group have upon the efficiency of its behavior," and "what effect does position in the group have on morale and job satisfaction." The reviewers concluded there was no clear answer to the first question, and that people in central positions are more satisfied than individuals in peripheral positions.

Studies that examined variations in communication structure (e.g., chain, wheel, star, all-channel networks) were reviewed, including an extensive series of communication network studies conducted by Shaw and mathematical analyses of communication networks by Christie and his colleagues. Glanzer and Glaser noted there was no empirical or rational basis for matching results from groups of different sizes even though they had the same structure, but one could definitely state that the number of distinct communication patterns decreased as the number of group members decreased. Unfortunately, they also concluded that no theory had been developed to explain and/or predict the learning that occurs in different networks or the differences in group performance obtained under different networks.

Glanzer and Glaser viewed these laboratory studies as being far removed from real-life situations. In particular, the laboratory studies sometimes arbitrarily restricted communication among group members, group members knew relatively little about the positions held by other members, and each member possessed information that was essential to solving only his task (e.g., if he was eliminated, success of the group was prevented -- member(s) could not compensate for the performance of another member).

Two other major areas of small group research were reviewed: that by Lanzetta and Roby on variations in communication structures more typical of military teams, and that by Rosenberg and Hall on the effects of different forms of feedback on group and individual behavior. Glanzer and Glaser viewed the contributions of these researchers as methodological (reducing real-life situations to laboratory settings), not theoretical, and that many of Lanzetta and Roby's findings established the obvious, e.g., if a subject has to check with many people before making a response, he is unlikely to complete the response in a short period of time.

Greenbaum, C.W. The small group under the gun: Uses of small groups in battle conditions. Journal of Applied Behavior, 1979, 15, 392-405.

The author suggested that small group researchers should not ignore studies of group processes within the military, that such studies provide important conditions for study (e.g., a framework for understanding behavior in situations involving strong social pressure or stress), and that many findings within small group experimental studies conflict with those found in combat situations. Research on the commitment of individuals to small military units and the performance of those groups in combat (World Wars I and II, Yom Kippur War, Korean War) was reviewed.

Three tentative conclusions were drawn from this body of research (p. 401-402): (a) properly led individuals in combat units will develop strong bonds of identification with one another --- these bonds are functional, serving to control individual fear and helping the individual to be effective in his work; (b) individuals will use others in the unit as a standard of comparison for competence, values, emotions, and a sense of well-being -- such comparisons are a product of pressure toward cohesion in the face of stress rather than a goal in themselves; and (c) the processes of affiliation and comparison contribute to the powerful influence which the small group exerts on the individual. These conclusions conflict with a body of experimental knowledge which maintains that people can be manipulated by authority alone, and that affiliation for the sake of emotional comparison is a primary goal of human beings in time of danger. Greenbaum concluded that small group research in the military may have more relevance for understanding social behavior in general, than much psychological research has for the military.

Hackman, J. R. Improving individual and group performance effectiveness. (Prepared for Office of Naval Research). New Haven, Conn.: Yale University, 1979. (DTIC No. AD A077 892)

The report described the work accomplished under a Office of Naval Research contract, with detailed results provided in the original reports of the referenced studies. One of the major efforts was development of a theory which specified the conditions under which individuals will experience internal motivation to perform high quality work and at the same time improve their task-relevant knowledge and skill. Another effort focused on the development and evaluation of

strategies for intervening into the group interaction process in order to increase team effectiveness and member satisfaction. Unfortunately, several research efforts, including a work redesign study within the Navy, were not completed either because of data analysis problems or difficulty in obtaining the appropriate organizations in which to conduct the studies.

Haines, D.B. *Training for group interdependence* (AMRL-TR-65-117). Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratories, Air Force Systems Command, July 1965. (DTIC No. AD 623 119)

A short review of cognitive, simulus-response, and gaming theories was presented, which focused on group interdependency principles that could be applied to Air Force teams such as bomber crews. A distinction was drawn between goal interdependency (where the goal achievement of any person in the group is linked to the goal achievement of all in the group) and means interdependency (where the means of seeking goals by an individual is directly influenced and affected by that of others in the group). Air Force teams are usually characterized by both goal and means interdependence.

The research reviewed showed the superiority of cooperation, as opposed to competition, when means interdependency exists. The recommendation was made that group leaders should emphasize shared rewards and abstain from individual rewards (e.g., airman of the month).

Hall, E. R., & Rizzo, W. A. *An assessment of U.S. Navy tactical team training* (TAEG Report No. 18). Orlando, Fla.: Training Analysis and Evaluation Group, March 1975. (DTIC No. AD A011 452)

Team training at Navy installations was observed, and research on team training was reviewed. Several problem areas were identified: "team" does not have a consistent meaning in the research literature nor within the military community, team skills are usually referred to in ambiguous terms (e.g., coordination, cooperation, team attitude), assessment of the effectiveness of teams is subjective, training objectives are rarely in behavioral terms, there is no systematic means of giving feedback to trainees while they are learning team skills, when feedback occurs it is in the form of error correction, and training for tactical-decision making is difficult (e.g., development of appropriate scenarios that are graded in terms of difficulty and prevent stereotype and perseveratory behavior). Little is known regarding what team training environments and sequences, and amount of individual training produce the most effective teams. The authors concluded that greater emphasis should be placed on individual training.

Heslin, R. Predicting group task effectiveness from member characteristics. *Psychological Bulletin*, 1964, *62*, 248-256.

Studies on the relationship of such individual characteristics as ability, adjustment, extraversion, dominance and authoritarianism to

group performance were reviewed. In general, member (or leader) ability and positive adjustment (degree of nervousness and tension) were related to group performance. Some of the studies used to support these conclusions involved Infantry rifle squads. The author concluded that the requirements of the group situation and social structural constraints must both be considered when attempting to predict group effectiveness from member characteristics.

Honigfeld, A. R. Group behavior in confinement: Review and annotated bibliography (Technical Memorandum 14-65). Aberdeen Proving Ground, Md.: U.S. Army Human Engineering Laboratories, October 1965. (DTIC No. AD 640 161)

The purpose of the review was to identify factors that would affect the performance of a tank crew during long periods of confinement in a buttoned-up tank and after release from confinement. Few of the studies reviewed provided data directly relevant to tank crew confinement and the tasks required of tank crew members.

Hood, P. D., and others. Conference on integrated aircrew training (WADD Technical Report 60-320). Wright-Patterson Air Force Base, Ohio: Air Research and Development Command, Wright Air Development Division, July 1960. (DTIC No. AD 240 638)

The papers within this document were from a conference on integrated aircrew training which focused on the relatively early use of aircrew simulators for Air Force training. Many of the research and training problems discussed are similar to those encountered today with Army teams and crews. There was a general consensus by the conference members that crew coordination and individual skill proficiency were both important elements of crew performance. The major points made by the presenters are cited below.

The first presenter, P.D. Hood, briefly reviewed the history of integrated crew training and then discussed some of the research conducted at Ohio State University and Castle Air Force Base. One instrument developed from this research was the Crew Operations Procedures (COP) test, which provided an indirect means of evaluating the level of coordination with a crew. Only nonstandard operating procedures were covered. The test presented a "canned" mission which had detailed requirements that the crew must meet and specified duties listed for each task area. Respondents/crew members were asked to indicate which members of the crew do what and when. Results with this instrument indicated that the more experience crewmembers had in flying together, the higher the COP agreement among crew members tended to be. No relationships were found between COP scores and crew performance, but COP scores did relate to superiors' ratings of crew proficiency.

Hood countered the argument that crew interaction may be so small that there is no need for integrated crew training, by stating that some of the problems that arise in combat depend greatly on crew coordination skills. Hood also stressed that much ingenuity is needed by the

instructor if training experiences which maximize the capabilities of the training equipment are to be presented to the crew.

Hood listed major research areas that need to be investigated: (1) coordination demands within the system; (2) group interaction variables among crew members and their influence on task performance; (3) nature and cause of variation in crew performance and procedures; (4) the effects that layout and design may have in facilitating or impeding crew efficiency; (5) effect of operational conditions on team performance (stress, fatigue, task, workload); (6) problems of assimilation, recall, transfer and use of technical information; (7) nature of learning, retention and transfer of skills and knowledge in crew coordination and cooperation; and (8) studies of problem solving, decision-making and crew tactical requirements. In addition, Hood stressed the need for a team of experts to observe the complexity of crew coordination, since this complexity makes such observation extremely difficult for single individuals.

The second presenter, R. L. Krumm, also discussed research on integrated crew training. He distinguished between two types of crew coordination: mechanical coordination, where individuals must synchronize their actions according to standard operating procedures; and response improvisation, where crew members must interact to solve problems for which a stock answer is not available.

Krumm described various measures that have been developed to examine crews: an Operating Procedures test, an academic cross-knowledge test (who does what within the crew), leader behavior description questionnaire, and various attitude scales. Krumm summarized the findings from the research as follows (p. 23):

> In the absence of specific rules regarding standard operating procedures crews will tend to develop their own procedures. These will be similar in most instances (because of equipment location and crew training) although inexperienced crews will tend to develop ways of accomplishing tasks that are unlike those used by more seasoned crews. As crewmembers gain experience in flying together, their attitudes toward each other are modified to become more accepting. Simultaneous with this attitude modification there develops an increase in flexibility. Crew interaction is increased to the point where depending upon circumstances existing at the moment, there is an interchange of responsibilities.
>
> Crews with less total flying experience seem to indicate a certain rigidity in accomplishing tasks, in the sense that there is a reliance on more fixed operating procedures. As these crews gain experience, they either discover for themselves improved ways of accomplishing tasks or they learn these from discussions with other crews. In either event, they conform to methods used by the majority of crews. These methods still do not prevent the

interchange of responsibilities noted above, as the situation demands it.

Krumm also reported on an experimental comparison of flight simulator training versus a control condition. The major conclusion was that the proper use of flight simulation in an integrated configuration was effective. However, he cautioned that the relationship between type of training received and outcome is not direct. For example, differences between the two conditions were found for navigator crew coordination scores but not for pilots.

Krumm discussed problems in measuring crew coordination, particularly when it involves response improvisation (e.g., the sampling and weighting of test situations, analysis of crew interactions, the problem of more than one good solution to a problem). The question of the relationship between individual and crew training was also raised.

R. T. Case discussed the problem of determining what defines a good aircrew. He stressed the importance of measuring performance over a sustained period of time and under actual combat conditions. Regarding the relationship between individual and integrated training, he stated that "until a student learns how to do what his crew station calls for he can't be worried about crew coordination" (p. 51).

Case stressed that the job of integrated crew trainers does not stop with the development of the hardware. Handbooks and guides regarding the best ways to use the equipment in training also need to be developed. Development of missions designed for the simulator are also critical, requiring input from equipment experts, military experts, and training specialists. Another factor to be considered is that instructor personnel must be sold on the concept of complete crew training, rather than thinking only in terms of the need for individual training.

The question was raised whether crew coordination can be guided or speeded up. Although there was no direct research evidence regarding this issue, the general feeling of the participants was that coordination has to be developed in a relatively unstructured manner.

Knerr, C.M., Berger, D.C., & Popelka, B.A. Sustaining team performance: A systems model (ARPA Contract No. MDA903-79-C-0209). Springfield, Va.: Mellonics Systems Development Division, March 1980.

Berger, D.C., Knerr, C.M. & Popelka, B.M. A systems model of team performance. Paper presented at the annual convention of the American Psychological Association, Division 19 (Military Psychology). New York City, August 1979.

The two purposes of the report were to examine variables that influence retention of individual and team skills within military teams and to develop a model that depicts the variables that influence team performance over time. The general model proposed was a systems model (input-process-output).

Three types of input were discussed: organization and environmental variables, individual input variables, and team input variables. Organization and environmental variables focused on such issues as personnel turbulence, selection and classification of personnel, and established vs. nonroutine tasks. The discussion of individual input variables stressed variables related to the retention of individual skills. Three major conclusions based on the literature review were (p. ii): (a) training to a high level of initial performance, rather than minimal initial training, enhances skill retention, (b) skill on procedural tasks decays more rapidly than on continuous control tasks, and (c) skill performance aids reduce reliance on memory thereby helping to sustain skill proficiency. Team input variables discussed were team composition and the nature of team tasks (e.g., Steiner's classification of tasks as disjunctive, conjunctive, etc.).

Processes were conceptualized in terms of formal and informal team structures and their relationship to task type, and various team processes that link team positions and mediate the effects of input variables upon team output. Such team processes were classified as adaptation, orientation, communication, etc.

The discussion of team output was based primarily on Steiner's process loss concept, that actual productivity equals potential productivity minus process losses due to communication and coordination requirements of team tasks, and on the relationship of task type to team productivity. Other concepts presented were the need for further work on developing team task taxonomies in order to apply instructional systems development (ISD) procedures to team training, role of feedback in team training, and criterion measurement of team performance.

Examples of Army teams and research on such teams were given throughout the report. In particular, indirect fire teams, Air Defense teams, tank crews, and Infantry rifle squads were cited.

Hypotheses derived from the literature review and analysis were as follows (p. iii): (a) practice and other mission-related experience maintains or improves skills in operational military units, even if it does not provide high fidelity training for individuals or teams; (b) task type and team size interact with team processes in their effect on team productivity; (c) increasing team size degrades performance if it increases communication and coordination requirements, decreasing requirements for interactive processes enhances team performance; (d) tasks performed in emergent situations benefit from team training, and tasks that are communication-oriented benefit from team training; and (e) team member ability strongly influences team productivity regardless of task type, team size, and other team performance variables.

Knerr, C.M., Nadler, L.B. & Berger, L.E. Toward a Naval team taxonomy (Interim Report, ONR Contract No. N00014-80-C-0871). Arlington, Va.: Mellonics Systems Development Division, December 1980.

The purpose of the report was to develop a taxonomy of team dimensions that could be used to describe differences in teams and to provide a framework

for conducting military team research. The taxonomy was based on a review of military and small group research, and consisted of five major components, which are outlined in more detail below (exogenous dimensions are starred). Much of the conceptual framework was based on Knerr et al.'s (1980) input-process-output systems model of team performance. A brief discussion of how each of these dimensions might be measured was also included.

Component 1: Members to Coordinate

1.* Team size
2. Member proficiencies
3. Member experience

Component 2: Nature of Task demands

1.* Type of task (Steiner's, 1972, classification of tasks as disjunctive, conjunctive, etc.)
2.* Task content (problem solving, monitoring, mechanical, etc.)
3.* Emergent-established tasks (reflects Boguslaw & Porter's, 1962, distinction between routine and non-routine tasks)
4.* Frequency of task
5.* Difficulty of task
6.* Number of solutions to task
7.* Unitary vs. divisible tasks (based on Steiner's, 1972, work)

Component 3: Network Established to Accomplish Task

1.* Degree of hierarchy (usually reflected by the chain of command and team member position/rank structure)
2.* Degree of communication centrality
3.* Sequential/parallel performance of tasks
4.* Role structure (e.g., position uniqueness, task designation, based on Dieterly's, 1978, analysis)

Component 4: Leadership Functions

1. Style of leader (democratic-autocratic)
2. Leader-member relations

Component 5: Communication Patterns

1. Processes (orientation, organization, adaptation, motivation, based on Nieva et al., 1978)
2.* Content (production, maintenance, innovation)
3. Other (e.g., task relevance)

Problems involved in defining teams in general and within the Navy were discussed. Methods for observing team processes/interaction were presented, mainly Bales' interaction process analysis and various forms of communication network analyses.

Of interest was the relationship made between Nieva et al.'s (1978) team functions taxonomy and team characteristics as identified in a prior survey of Army teams (Dyer et al., 1980). In particular, specific examples of each team function were taken from the team characteristics survey (an example of orientation was obtaining information about the team's goals and missions; an example of organization was leader coordination, an example of adaptation was mutual timing by team members when performing a task, an example of motivation was team spirit). Questionnaire items were then developed for each of these subcategories in order to assess the team need (is X required for this team?), team availability (could/can X be done?), and actual team behavior (to what extent was X actually done?). No data were collected with this preliminary measurement technique.

Lorge, I., Fox, D., Davitz, J. & Brenner, M. A survey of studies contrasting the quality of group performance and individual performance, 1920-1957. Pyschological Bulletin, 1958, 55, 337-372.

The reviewers discussed six major types of groups that have been used from 1920 to 1957 in "group" research (p. 340):

1. Interacting, face-to-face groups (group meeting and discussion)
   a. with a tradition of working together (traditioned)
   b. with no tradition of working together (ad hoc)

2. Noninteracting face-to-face groups (physical meeting, but no discussion)
   a. with a sequel appraisal of group opinion (climatized)
   b. with a sequel appraisal of individual opinion (social climatized)

3. Noninteracting non-face-to-face groups (no meeting and no discussion)
   a. averaging of individual performances (statisticized)
   b. combining of individual performances (concocted)

They stressed that it was a common but dangerous practice to generalize the principles valid for ad hoc groups to traditioned groups, treating the ad hoc group as a microscopic model of the traditioned group. Such an assumption had not been experimentally validated at that time.

McGrath, J.E., & Altman, I. Small group research: A synthesis and critique of the field. New York: Holt Rinehart & Winston, 1966.

A systematic classification of small group research studies was presented with summaries of 250 studies. Two classification systems were presented: an operational and a substantive system. The outlines for each are presented below.

Operational Classification System (classification system for each item of data)

1. Object: What entity is being observed of judged?

   a. Member (self, other)

b. Group
c. Surround (individual, group, nonhuman object)

2. Mode: What is it about the object that is being recorded?

a. State
b. Action

3. Task: In what terms is the respondent judging the object?

a. Descriptive
b. Evaluative

4. Relativeness: Is the judgement a comparative one or absolute?

5. Source: Who/what is making the response or judgement about the object?

a. Member
b. Group
c. External (investigator, instrument)

6. Viewpoint: From whose point of view does the source make his judgements or response?

a. Subjective
b. Objective

Substantive Classification system

1. Properties of group members

a. Biographical characteristics
b. Personality characteristics
c. Abilities
d. Attitudes
e. Positions of members in the group

2. Properties of the group

a. Group capabilities
b. Interpersonal relations in the group
c. General structural properties of the group

3. Conditions imposed on the group

a. Social conditions
b. Task and operating conditions

4. Interaction processes

a. Content of interaction

b. Pattern of interaction
c. Outcomes of interaction

5. Subjective measures of member and group performance

   a. Perceptions of task performance of self and others
   b. Perceptions of social behavior of self and others

6. Objective measures of member and group performance

   a. Leadership performance
   b. Task performance of members
   c. Task performance of groups

McGrath and Altman gave a brief summary of the research findings and cited research areas that should be addressed. A summary of these findings is not presented here. However, some interesting points were made. We need to know how various tasks or social positions of members contribute to over-all group performance. One might predict that the more central a member's position in the group, either physically or functionally, the greater his contriubtion to group performance. Research shows that as groups practice they get better. However, little research exists on how practice has an impact, in terms of intermediate processes and events. Research does not fully support the adage that the more capabilities members possess the better group performance will be; when peers make subjective judgements of capabilities this relationship is even less clear-cut. Two research areas stressed by the authors were a need to understand the sequential links between group inputs, intermediate group processes, and final group performance, and to become more sensitive to the parameters and properties of different types of performance.

McGrath and Altman also cited methodological weaknesses in the small group area. The failure to replicate studies and the lack of a common, shared language makes it extremely difficult to successfully accumulate knowledge within the area. There is little research that systematically progresses from the lab to the field. The variable of time has been ignored. There is a need for longitudinal studies that examine developmental patterns in group processes. Most observation systems developed to tabulate interaction processes are inadequate for the study of groups. Group composition is often ignored or background variables are just summed across members. Finally, the entire area is characterized by too much data and too little theory. By theory, the authors meant systematic attempts to formulate sets of principles, postulates, and hypotheses about relationships among variables, not descriptive models.

Meister, D. Behavioral foundations of system development. New York: Wiley, 1976.

Two chapters from Meister's book are particularly relevant to team research: Chapter II on task characteristics and Chapter IV on team

functions. In Chapter II Meister listed several major properities of tasks: temporal relations, psychological functions, dependence among subtasks, complexity, task organization, divisibility, difficulty, criticality, and automation.

In the chapter on team functions, he cited some critical research questions and derived conclusions from team research studies. It should be noted that some conclusions were based on relatively few studies. The conclusions were as follows: organizational size is negatively or curvilinearly related to output, to working morale, and quality of work; crew composition significantly determines crew member behavior; personnel turnover effects depend upon the role of the individual being replaced; the extent to which team output can be predicted from individual performance depends upon the degree to which group performance is dependent upon individual proficiency; in general 50% of the variance in team performance is not attributable to individual performance; procedural flexibility within a team interacts with stress, under normal conditions teams operate effectively with flexibility while under stress too many options may hinder performance; a hierarchical team structure is usually preferred to serial structure; interactions among team members should be minimized in order to enhance performance; teams will adjust to varying loads if their operating procedures are flexible; during training, teams in highly uncertain situations should have the opportunity to establish their own operating procedures; high fidelity training conditions are important to task performance; irrelevant communication can have negative effects upon team performance; when both visual and verbal modes of communication are possible the visual mode is more effective; the more direct the transmission within a team, the better; and communication training has had little effect upon team performance.

Research questions that need to be addressed were: What types of nonverbal interactions occur within teams; are such interactions trainable; how do interactions reflect team performance and what is the effect of communication upon system output; how do you determine who is in the team; how do you determine what is a measureable unit of team activity; how homogeneous does a team have to be; what is the effect of turnover in personnel and does this effect vary with skills required and type of task; are contributions of team members to output variables equal or differentially weighted and how can we explain this; how well can we predict team and system output from the combined performance of individual team members; what is being learned when a team is being trained as a team (if we can't specify this, then we can't control training nor plan for it); does team training exhibit the same characteristics as individual training; what is the relationship between individual and team training; does team training really improve system output; and are the major variables that influence individual training (e.g., type of task, feedback, learning ability) the same as those that influence team training.

Nadler, D.A. The effects of feedback on task group behavior: A review of the experimental research. Organizational Behavior and Human Performance, 1979, 23, 309-338.

Although there is an abundance of information/theories/models on the effects of feedback to individuals, Nadler found little corresponding information with regard to group feedback. He applied Vroom's distinction among the cue, learning, and motivational functions of feedback to 34 studies on feedback in task-oriented groups. He concluded that feedback to the group as a whole has an effect upon an individual's attitudes toward the group (e.g., attraction, involvement) and influences task motivation; while feedback to individuals within the group is more effective in directly influencing individual performance. In fact, in some cases group-level feedback may provide inappropriate cues to some group members. In tasks, where the group performance was simply the sum of individual performances, then individual feedback was found to be best. Affiliation oriented individuals preferred group feedback, while task or achievement-oriented individuals responded to individual feedback. Although feedback may improve functioning its evaluative content may promote defensiveness and negative attitudes. There was little research on how groups use feedback information and on the role of feedback given during the group process.

Nieva, V.F., Fleishman, E.A., & Rieck, A. Team dimensions: Their identity, their measurement and their relationships. Washington, D. C.: Advanced Research Resources Organization, November 1978.

The authors reviewed small group research for factors that affect group performance. Based on this review a model of team performance and a provisional taxonomy of team performance dimensions were presented.

Nine variables affecting group performance were examined: group size, group cohesiveness, intra-group and inter-group competition and cooperation, communication, standard communication nets, homogeneity/heterogeneity in personality and attitudes, homogeneity/heterogeneity in ability, power distribution within the group, and group training. A summary of the findings for each variable was included.

A provisional taxonomy of team functions was developed to reflect dimensions that specify what a team does interactively to accomplish an objective. The taxonomy is as follows:

Team Orientation Functions: Processes by which information necessary to task accomplishment are generated and distributed to team members.

1. Elicitation and distribution of information about team goals
2. Elicitation and distribution of information about team tasks
3. Elicitation and distribution of information about member resources and constraints

Team Organizational Functions: Processes necessary for the group members to perform their tasks in coordination with each other.

1. Matching member resources to task requirements
2. Response coordination and sequencing of activities
3. Activity pacing
4. Priority assignment among tasks
5. Load balancing of tasks by members

Team Adaptation Functions: Process that occur as team members carry out accepted strategies and complement each other in accomplishing the team task.

1. Mutual critical evaluation and correction of error
2. Mutual compensatory performance
3. Mutual compensatory timing

Team Motivational Functions: Processes involving defining team objectives related to the task and energizing the group towards these objectives.

1. Development of team performance norms
2. Generating acceptance of team performance norms
3. Establishing team-level performance-rewards linkages
4. Reinforcement of task orientation
5. Balancing team orientation with individual competition
6. Resolution of performance-relevant conflicts

Sells, S.B. Military small group performance under isolation and stress. Critical review II. Dimensions of group structure and group behavior (Technical Documentary Report AAL-TDR-62-32). Fort Wainright, Alaska: Arctic Aeromedical Laboratory, June 1962. (DTIC No. AD 288 689)

The report was essentially a discussion, from a managerial point of view, of the effect on group behavior of fourteen group structure dimensions (developed by Hemphill in 1956). Little research was cited. The fourteen dimensions were: autonomy (extent to which group activities are independent of activities performed by other groups), control (degree to which group regulates members' behavior), potency (degree to which group satisfies member needs), procedural rigidity or flexibility, permeability of membership rules (entrance to or leaving group), polarization (degree to which group is oriented to a goal), stratification of members, participation (in activities promoting the group or voluntary assumption of nonassigned duties), stability (with respect to personnel, role relations, organization, and size), homogeneity of personnel (with respect to traits relevant to group work), interpersonal acquaintanceship of members, affect created by participation in the group, cohesiveness (degree of teamwork), and size of group.

Steiner, I.D. Group process and productivity. New York: Academic Press, 1972.

Steiner's theory of group productivity assumes that productivity depends upon three major variables: task demands, resources, and process. Task demands specify the kinds and amounts of resources that are needed, and how

they are to be used if maximum productivity is to be obtained. Resources refer to the types and amounts of knowledge, abilities, skills and tools actually possessed by the group. Process consists of the actual steps taken by an individual or group when confronted by a task.

Task demands and participants' resources together determine the maximum level of productivity that can be achieved. Steiner defined potential productivity as the maximum level of productivity that can occur when an individual or group employs its fund of resources to meet the task demands. The appropriateness of group processes then determines how well the group's actual productivity approximates its potential productivity, i.e., actual productivity = potential productivity - losses due to faulty processes.

Steiner distinguished between divisible and unitary tasks. Unitary tasks cannot be easily or profitably broken into smaller parts, whereas division of labor is feasible with divisible tasks. However, unitary tasks differ in the ways they permit members to combine their individual efforts or products. In particular, Steiner identified four types of tasks: disjunctive, conjunctive, additive, and discretionary. With disjunctive tasks, the group product is determined by only one individual, that is, the group can only accept one of its member's contributions (for example, groups must determine which of several alternatives is the correct solution to a problem). With conjunctive tasks, everyone must perform the task and the group output is determined by the member who does least well (for example, a platoon of soldiers can move no faster than the slowest member). In additive tasks, each member takes his turn, but group success depends upon the sum of the individual efforts. Discretionary tasks permit members of a group to combine their individual contributions in any manner they wish (assign total weight to one person, weight each equally, grant each person a different weight).

With divisible tasks, unitary subtasks can be identified and classified as either disjunctive, conjunctive, additive or discretionary. In turn, the process by which the subtasks are combined to form the final group product can be classified as disjunctive, conjunctive, additive or discretionary.

Most of the text focused upon factors that interact with task type to affect potential and actual productivity. These factors includedgroup size, group composition (heterogeneity/homogeneity of individual abilities within the group), motivation (rewards, payoff systems), and difficulties in matching resources and process with tasks.

Turney, R., Cohen, L., & Greenberg, Targets for team skills training (Prepared for Office of Naval Research). Columbia, Md.: General Physics Corporation, April 1981. (DTIC No. AD A099 333)

The report reviewed research on the training of team skills, primarily the use of verbal communication to coordinate team efforts. Eight studies that focused on military teams/contexts and six additional studies with small groups which focused on training interventions were examined. The authors concluded that skill training that focuses on interpersonal skills at a general level and is not tied directly to formal task requirements is not likely to have strong impacts upon team performance; that good and bad teams

can be distinguished from each other in terms of communication variables; and that teams can be trained to use interpersonal communications more effectively.

Several other issues were discussed: lack of clear guidance in the literature regarding how to operationally measure team skills, which reflects the more general problem of conceptualizing what is meant by such terms as coordination, cooperation, and collaboration; lack of performance criteria for teams and the need to separate team from individual skills on such criteria; and determining how to identify the tasks that require team training (emergent tasks were given as an example of tasks where team training is needed).

Wagner, H., Hibbits, N., Rosenblatt, R.D., & Schulz, R. Team training and evaluation strategies: State-of-the-art (HumRRO TR-77-1). Alexandria, Va.: Human Resources Research Organization, February 1977. (DTIC No. AD A038 505)

The purpose of the report was to review team training research and evaluation techniques for team training, and to recommend areas for future team research. The authors discussed the problem of defining "team" and of distinguishing team training from multi-individual training.

Prior research in team training was classified on two dimensions: the training focus (team training vs. multi-individual training) and the task situation (emergent vs. established tasks). Research studies on team vs. individual training, training for team skills such as cooperation, simulation fidelity, feedback/knowledge of results, and team structure and composition were categorized in this two-dimensional system. Existing techniques and procedures for evaluating team training within the military were also placed within this system.

Two major conclusions from the research studies reviewed were that the team context is not the proper location for initial individual skill acquisition, and that performance feedback is critical to the learning of both team and individual skills.

The major research questions identified were: what methods of providing team feedback are most useful, will self-assessment training result in greater team proficiency, will assessment of other team members' performance affect team proficiency, what degree of simulation fidelity is critical, does degree of simulation fidelity depend upon whether the task is emergent or established, how does turbulence in team personnel affect proficiency, and what sequence of individual and team skill training is most effective.

B. MODELS AND/OR THEORIES OF TEAM BEHAVIOR

The articles in Section B focus on models and theories of team/small group behavior. The material presented in these articles varies greatly in terms of the comprehensiveness and detail of the theory or model. The classification list below describes the major emphasis of these articles.

1. Organismic vs. Stimulus Response Models

   Alexander & Cooperband (1965)
   Boguslaw & Porter (1962)

2. Systems Models (Input-Process-Output)

   Finley et al. (1969, 1970)
   Hackman & Morris (1975)
   Knerr, Berger & Popelka (1980)
   Roby (1968)
   Shiflett (1979)

3. Cybernetic Models

   Taylor (1979)

4. Mathematical Models

   Lowe & McGrath (1969)
   Roby (1968)
   Shiflett (1979)
   Siegel & Miehle (1967)
   Siegel et al. (1969, 1971)
   Steiner (1966, 1972)

5. Tasks/Task Structure

   Alexander & Cooperband (1965)
   Boguslaw & Porter (1962)
   Dieterly (1978)
   Naylor & Dickinson (1969)
   Shaw (1976)
   Steiner (1972)
   Thibaut & Kelley (1959)
   Zajonc (1965)

6. Leader Functions

   DeLuca & Wagner (1969)
   Henriksen et al. (1980)
   Shriver et al. (1980)

7. Cooperation/Coordination Demands

   George (1967b)
   Jordan et al. (1963)
   Thibaut & Kelley (1959)

8. Group Development

   Tuckman (1965)

Alexander, L.T. & Cooperband, A.S. System training and research in team behavior (TM-2581). Santa Monica, Calif.: System Development Corporation, August 1965. (DTIC No. AD 620 606.)

See reference in Section A. The authors discussed two theories of team behavior, called the organismic and stimulus-response models. A model of team behavior in emergent situations was also presented.

Boguslaw, R. & Porter, E.H. Team functions and training. In R.M. Gagne' (Ed.), Psychological principles in systems development. New York: Holt Rinehart & Winston, 1962, pp. 387-416.

See reference in Section A. The authors elaborated on the concept of team functions for both established and emergent team situations.

DeLuca, A.J. & Wagner, G.J. Critical combat performance, knowledges, and skills required of the Infantry rifle platoon leader: Squad formation battle drill, and elementary fire and maneuver. Washington, D.C.: George Washington University, Human Resources Research Office, June 1968. (DTIC No. AD 704 987)

The behaviors, knowledge, and skills required of an Infantry rifle platoon leader are presented. The areas covered are squad formations, battle drill, and elementary fire and maneuver. An underlying assumption was that a rifle platoon/squad must be able to act quickly in combat to unexpected situations, with the best results occurring by selecting the alternative the enemy least expects. To do this, the leader must have prearranged procedures that are well understood by all. The list of skills and knowledges presented is not a list of do's and don'ts, but of basic principles that the platoon/squad leader must understand (e.g., understands that the squad leader places himself within the formation where he can best exercise control; knows that the maneuver element advances by fire team movement, fire and movement within the team, or creeping and crawling depending upon the terrain and effectiveness of the supporting fire). (Note - The list may be outdated by changes in doctrine and tactics.)

Dieterly, D.L. Team performance: A model for research. In E.J. Baise & J.M. Miller (Eds.), Proceedings of the Human Factors Society, 22nd Annual Meeting. Santa Monica, Calif.: Human Factors Society, 1978.

A short review of team research and a model of team performance were presented. The model depicted team performance as a function of the individual skills of team members, task function design, and the interaction between individual skills, task function design, and the three process dimensions of communication, control, and decision-making.

Dieterly proposed several ways of analyzing team tasks, ie., task function design (p. 400-401). Within team operations there are two types of tasks: those that are not dependent upon a team context and

those that are only present in a team context. Four characteristics were cited for each set of tasks.

Tasks not Dependent upon a Team Context

1. Standard vs. emergency tasks (emergency tasks are encountered under error conditions).

2. Whether or not a task must be executed sequentially after another task.

3. Uniqueness/nonuniquess: A unique task must be completed in order to obtain an objective; a non-unique task should be accomplished but is not necessary for attainment of the objective.

4. Criticality: A critical task is key to the completion of a set of tasks; occurring at a specific point in time and must be accomplished. A non-key task is one that is incidental; it must be accomplished but not at any specific point in time.

Tasks Dependent upon Use of a Team

1. Position unique or non-unique. A position unique task is one that can only be accomplished by the individual in that position. A non-unique task can be accomplished by any team member.

2. Designated or nondesignated tasks. A designated task is one that the team expects to be accomplished by a specific member. If a task is non-designated any member may be required to complete it.

3. Interdependence. A task is dependent, if its completion depends upon the completion of another task by another team member.

4. Management control of tasks refers to the ability to reallocate tasks after the team begins to function.

Another concept proposed by Dieterly that is generalizable across teams was that of task interdependency (different from the concept of interdependence just cited). This is the ratio of the total number of tasks required to accomplish an objective within a reasonable period of time to the maximum number of tasks a single member can handle. A task interdependency ratio of one reflects a team situation where one member has the capability to perform all tasks. A value exceeding one would indicate an objective that may only be obtained by two or more members.

Dieterly also stressed the imprecise definitions within the team research field, the little amount of research examining team processes, the superficial way in which team training has been examined, and the necessity to define characteristics unique to teams in order to train teams (is not sufficient to train to individual positions and then expect appropriate team interactions to occur automatically).

Finley, D.L., Obermayer, R.W., Bertone, C.M., Meister, D. & Muckler, F.A. <u>Human performance prediction in man-machine systems</u> (Volume I). <u>A technical review</u> (NASA CR-1614). Canoga Park, Calif.: Bunker-Ramo Corp., August 1970. (STAR N70-35379)

Finley, D.L., Obermayer, R.W., Bertone, C.M., Meister, D. & Muckler, F.A. <u>Human performance prediction in man-machine systems</u> (Volume III). <u>A selection and annotated bibliography</u> (NASA Contract No. NAS2-5038). Canoga Park, Calif.: Bunker-Ramo Corp., August 1969. (STAR N71-27251)

The major focus of the documents was on prediction of human performance in man-machine system tasks. Although most of the measures examined focused on individual performance, some measures of group performance were included as well (Vol. III).

The authors hypothesized (Vol. I) that group performance can be predicted from individual member output if the group task consists of separate procedures performed by individual members and if the input-process-output flow is a simple one. However, if group activities are more complex then prediction of group output must also include group performance and group composition dimensions. Four group composition dimensions were cited: perceived similarity, group compatability, group cohesiveness, and leadership. Twelve dimensions that describe group performance in either the input, processing, or output stage were hypothesized: sensitivity or discrimination, manipulation, speed, selection, flexibility, knowledge, memory, general reasoning, deduction or analysis, integration or coordination, prediction or feedback usage, and stamina (p. 95).

George, C.E. The view from the underside -- Task demands and group structure. In J.A. Olmstead, P.D. Hood, C.E. George, & T.O. Jacobs (Eds.), <u>Goal-directed leadership: Superordinate to human relations?</u> (HumRRO Professional Paper 11-67). Alexandria, Va.: Human Resources Research Office, March 1967. (b) (DTIC No. AD 649 864)

In this paper George distinguished between crews and teams. Both have a high degree of structure (hierarchically organized groups of fixed size that have many and different roles for team members), but crews have a more rigid structure (a higher level of role specialization) than do teams. Teams and crews also differ in the form of coordination required among members. Coordination requirements within crews tend to be sequential, communication is facilitated by the fact that crews usually work in a restricted space and around a machine, and members can usually predict what response they must make and when to make it. On the other hand, team members (e.g., rifle squads) are not tied together by a single machine, are not necessarily in easy sensory contact with one another, and cannot easily predict what response they may have to make at any given moment.

George used this team-crew distinction to explain why some researchers have found training in coordination and compensatory behavior to improve performance and others have not. Such training should help teams more than crews. The remainder of the paper reviewd the same studies of rifle squads as cited in the George (1967a) reference.

Hackman, J.R., & Morris, C.G. Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), Advances in experimental social psychology, Vol 8. New York: Academic Press, 1975, pp. 45-99. (DTIC No. AD 785 287)

An input-process-output model for small group performance was presented and new directions for small group research were discussed. Input factors (individual, group, and/or environmental input) were assumed to affect group performance through the interaction process and problem-solving tasks were assumed to involve continuous recycling through the input-process-output system.

The following research needs were cited. Many studies have examined input-process relationships, but few studies have examined either process-performance relationships or input-process-performance relationships. Different behavior categories should be examined when observing group process. In particular, there is a need to focus on aspects of group interactions that are critical in determining group effectiveness, in addition to just being able to describe what happens. Sequences of interaction, rather than summary frequencies or rates of interaction, need to be recorded so that interaction sequence can be related to task goals and strategies pursued by group members. Procedures that permit analysis of more than two people over relatively long periods of time need to be developed. A system for categorizing small group tasks needs to be developed, and process-performance relationships should then be examined within classes of tasks.

The authors assumed that a major portion of the variation in group effectiveness is controlled by three "summary" variables: (a) effort expended on the task by group members, (b) task performance strategies used by group members in carrying out the task, and (c) knowledge and skills of group members. Each of these summary variables can be substantially affected, either positively or negatively, by what happens in the group interaction process.

It was proposed that group interaction affects member effort by influencing both the coordination of individual efforts and the level of effort members choose to expend on the task. Group interaction affects task performance strategies through implementing pre-existing strategies shared among group members or through reformulating existing performance strategies. (Research shows that most small groups in laboratory settings do not discuss their strategy for performing the task at hand.)

Group interaction influences the effectiveness with which individual skills and knowledge are applied to the task by weighting the possible contributions of different members or by creating group conditions that will

lead to a change in the overall skill level which individual members are able to apply to the task. For tasks where individual skills are important in determining group performance, it is often possible to predict how well the group will do solely on the basis of the talent of its members. One example of such a situation is where group interaction serves merely as a vehicle for exchanging data, leaving little opportunity for process foul-ups (process loss). Process loss is apt to be higher, and therefore prediction of group effectiveness from individual skills is apt to be lower, when the specific skills required are not obvious, when obtaining a solution involves complex teamwork, or when sophisticated or subtle social processes are required to identify the necessary individual talents and apply them to the task.

The authors also briefly discussed how one might modify group effectiveness on problem-solving tasks by varying input factors, task performance strategies, member effort and member skill/knowledge.

Henriksen, K.F., Jones, D.R., Hannaman, D.L., Wylie, P.B., Shriver, E.L., Hamill, B.W., & Sulzen, R.H. Identification of combat unit leader skills and leader-group interaction processes (ARI Technical Report 440). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1980.

Leader skills and leader-group interactive processes that could influence unit performance in tactical military situations were identified through a literature review of leader research and theory, an examination of historical engagement simulation data, and the personal combat experiences of the authors. Restriction of leader skills to tactical situations distinguished this report from others on general leadership dimensions. If a skill category identified in the literature review was also identified in the engagement simulation/combat analysis, then the category used in the literature was retained in the final model. However, many of the skill categories identified in the engagement simulation/combat analysis did not have counterparts in the research literature. Five broad leader skill categories (not mutually exclusive) were identified: management skills, communication skills, problem solving skills, tactical skills, and technical skills. A more detailed description of these categories and their subcategories is given below.

Management skills: Refers to the efficient handling of assets including people, equipment, and support elements.

a. Planning: Formulating the means by which a tactical operation is to be executed and achieved. A well-formulated plan takes into account all things normally included in Army operations orders (objective, enemy situation, friendly situation, concept of operation, execution, and command and signal).

b. Execution and Control: Control of men refers to the direct command and control in a field operation, while execution refers to timely and decisive actions and organizing ability.

c. Initiating Structure: Refers to the extent to which leaders are likely to define and structure their roles and those of their subordinates toward goal attainment. It involves acts that demonstrate that the leader organizes and defines tasks to be completed, that people are assigned to particular tasks, and that deadlines are set.

d. Interaction with Subordinates and Superiors: Refers to the degree to which an individual's interactions with subordinates and superiors promotes mutual trust, respect, high morale, group cohesiveness, and progress toward goal attainment.

Communication skills: Refers to effective transfer and receipt of information by the leader.

a. Transfer of Information: Extent to which the leader transmits planned information and transmits new information to all appropriate individuals during conduct of operation.

b. Pursuit and Receipt of Information: Pursuit refers to the degree to which the leader actively seeks out needed information and tries to keep informed on all matters pertaining to the mission, while receipt refers not only to whether vital information is relayed back to the leader but also to whether he is open and receptive to that information.

Problem-Solving Skills: Refers to coordination of complex processes such as organizing information, generating ideas, and evaluating alternative courses of action.

a. Identification and Interpretation of Cues: In tactical situations a cue is either a sign of or contact with the enemy. Identification is defined as recognizing a cue as an indication of an opposing force's actions, intentions, or presence. Interpretation of an identified cue was defined as deducing the opposing force's disposition given the cue(s).

b. Weighing Alternatives: Involves assessing the likely consequences of various actions.

c. Choosing a course of action: After weighing the alternatives, a course of action which leads to favorable consequences must be chosen in a timely manner.

Tactical Skills: Application of tactical knowledge constitutes leader tactical skills (i.e., combining portions of acceptable tactics, developing new tactics, or varying existing tactics).

Technical Skills: Effective use of equipment and basic skills.

a. Equipment: Effective use of equipment, i.e., tactical vehicles, communication equipment, and weapons. Proficiency in the use of weapons involves matching weapons with potential targets, selecting

the appropriate weapons for engaging an enemy when several weapons are available, and effectively deploying weapons in a manner that permits their use to complement one another.

b. Basic Skills: Basic skills refer to skills that significantly contribute to the outcome of a tactical situation and occur frequently. Proficiency in map reading and terrain analysis were identified. Skills in first aid, chemical warfare, rappelling, etc. were examples of basic skills that contribute to a tactical situation, but not to a significant degree, and therefore were not included in this category.

An important feature of the report was that examples of each of these skills were cited, based on combat experience and engagement simulation (primarily Infantry and Armor) exercises. Leader observation checklists were developed to measure the existence of the leader skills in tactical situations. The relationship between the leader skill categories and individual skills was also tabulated.

Jordan, N., Jensen, B.T., & Terebinsky, S.J. The development of cooperation among three-man crews in a simulated man-machine information processing system. Journal of Social Psychology, 1963, 59, 175-184.

A four stage model of the development of team cooperation was discussed. The stages were: formulating an individual model of the system within which each individual operates; formulating a homologous model (development of some agreement among team members with respect to their individual models); the emergence of trust; and learning to cooperate.

Knerr, C. M., Berger, D.C., & Popelka, B.A. Sustaining team performance: A systems model (ARPA Contract No. MDA903-79-C-0209). Springfield, Va.: Hellonics Systems Development Division, March 1980.

See reference in Section A. Team behavior was conceptualized in terms of a systems (input-process-output) model.

Lowe, J.H., & McGrath, J.E. Prediction of characteristics of group output from individual performance characteristics (AFORS - 69 -2470TR). Urbana, Ill.: University of Illinois, Department of Psychology, August 1969. (DTIC No. AD 700 103)

The first section of the report reviewed various mathematical models that have been proposed for predicting group performance from individual performance (e.g., Steiner's conjunctive and disjunctive equations). The study itself examined several types of group (four-man) intellectual tasks that required a written product. The mathematical group-prediction models developed by previous researchers were applied to data obtained from the study, and in general yielded similar results. Multiple correlation results showed that certain properties of written group products were relatively predictable from measures of those same properties obtained from the written products of the individual

members. Despite the relative success of the predictions, many additional issues were raised regarding the development of adequate mathematical models for predicting group performance.

Naylor, J.C., & Dickinson, T.L. Task structure, work structure, and team performance. Journal of Applied Psychology, 1969, 53, 167-177.

Team performance was posited to be a function of three factors: task structure, work structure, and communication structure. Task structure, in turn, was defined in terms of three factors: component complexity (the information-processing and/or memory-storage requirements of the task), component organization (demands imposed by the total task due to the interrelationship existing among task components), and component redundancy (degree of overlap existing among the demands imposed by the several individual task components). Work structure was defined as the manner in which the task components are distributed among team members (i.e., definition of the operations to be performed, the sequence in which these operations must occur, and the way in which interaction among team members must occur). Communication structure (communications among team members) was viewed as being a consequence of the particular work and task structure characteristics of the task at hand. This definition involved only those communication networks worked out by team members, not aspects of communication among members that were intrinsic to the nature and design of the task.

With the particular laboratory task examined using two-man teams, task structure affected team performance, whereas work structure did not.

Roby, T.B. Small group performance. Chicago: Rand McNally, 1968.

Roby developed a model of small group performance, presented mathematical formulations of the small group process and functions identified in the model, and illustrated these processes/functions with laboratory studies. Roby restricted the model to groups where the task is clearly defined, task performance occurs during a distinct time interval, task objectives and conditions are understood and accepted by individual members, and the group has performed within the task situation long enough so that the roles of individual members have become established. In brief, the model assumes that group performance results from input to the group from the task environment, at which point such observations are "digested" and placed in the service of an "executive" faculty, which in turn relates the input information to the group's goals and tactics, producing prescriptions for group action or behavior. The result is an instrumental action which modifies the task environment to some degree and initiates a new performance cycle.

Roby's model illustrates the complexity of group functioning and identifies potential areas for future research. The following group processes and subfunctions were identified in this general model.

Primary Input Subfunctions

1. Observation. The first concern of the group is to obtain information from the task environment. Individual perception is involved, but such behavior is also influenced by the position held by each individual.

2. Information Routing. Once observation occurs, then communication among group members is aimed at disseminating this task environment information. It is assumed that certain items of information are directly available to some members but not to others. Information routing is concerned with the processes by which the remaining group members may obtain information which they initially do not have, but need. It is rarely the case that complete dissemination of all information to any group member is desirable or feasible. What is actually communicated is balanced between what is desirable (i.e., required for decisions) and the feasibility of communication.

3. Storage and Forecasting. This subfunction refers to the way in which information that is obtained directly from the task environment is reflected in informational states at later times. Storage is required if there is a lag between the time information is observed and the time information is used in decision making. Closely related to storage is the forecasting function that is necessitated by gaps between the time observations are made and the time decisions are to be applied. Issues raised are how do individuals determine information requirements and pull-out only the essential material, how do individuals deduce existing and future states, how is information retained, and how are these functions divided up among group members.

4. Patterning. Raw observations are transformed into more compact and directly useful forms through patterning. This is a critical problem for groups since scattered bits of information may never get collected into a whole.

Primary Output Subfunctions

1. Action Potential. Action potential refers to estimation of the overall capability of a group for instrumental action. It depends on the proficiency of individual group members, distribution of skills

among group members, and the space-time structure which determines the way skills are demanded of the group by the task environment.

2. Executive Structure. This function converts the group's overall picture of current environmental conditions into a set of prescriptions for action. Of particular interest are conditions where group action is determined by a number of fragmentary decisions often made independently of each other and perhaps on the basis of different information, and where the value of any particular action depends not only on the environmental circumstances but also upon other actions that are taken concurrently.

Secondary Control Processes

Since typical group performance involves continuous or successive inputs from the task environment, a complete picture of groups must incorporate processes that cut across cycles. The cumulative effects of actions, pacing of the performance cycle, and procedural changes as a result of task experience are important considerations. The following functions are involved in this continuous process.

1. Mapping and Planning. In mapping, the group must establish what aspects of the task environment are relevant and how they bear on specific decisions. In planning, the group must apply known environmental information to a series of actions.

2. Addressing. This function focuses on each member's knowledge of the relevant activities of other group members, and includes both long range learning of the special roles and positions of other members which govern their access to or need for certain types of information, and ad hoc signaling of unpredictable information needs.

3. Phasing. Phasing refers to the coordination of activities between group members and pacing of activities with respect to environmental events. Group problems in this area include formalizing the phasing requirements for certain tasks, describing the group's learning of these requirements, and specifying the signaling system required for a given set of phasing relations.

Shaw, M.E. Group dynamics: The psychology of small group behavior (2nd ed.). New York: McGraw-Hill, 1976.

The sections of Shaw's text that dealt with the task environment and performance of small groups are relevant to this report. Shaw modified Steiner's concept of actual group productivity to account for situations where the group process may increase group productivity beyond the potential productivity estimated from individual performance. Steiner's concept suggested that group processes have only negative effects on actual productivity. Shaw's revised concept defined actual productivity as equal to potential group productivity (based on individual

performance estimates) minus losses due to faulty group process plus gains due to group process.

Shaw identified three situations where group action is preferable to individual action: tasks that cannot be conducted by a single individual, where group products may be superior to individual products (e.g., accuracy versus speed), and where group decisions may be more readily accepted and implemented than individual decisions.

To date, three general approaches have been used to examine/study/control small group tasks: development of a standard small group task for use in research studies, classification of tasks into specific categories (e.g., simple/complex, production/discussion/problem solving, disjunctive/conjunctive/additive/discretionary), and dimensional analysis of group tasks (e.g., Shaw's dimensions of difficulty, solution multiplicity, intrinsic interest, cooperation requirements, population familiarity, intellectual-manipulative requirements).

Shiflett, S. Toward a general model of small group productivity. Psychological Bulletin, 1979, 86, 67-79.

A general, rather abstract, mathematical model was proposed which described the ways in which individual resources are transformed into a group product through group processes. Three classes of variables were discussed: resources (the knowledge, ability, and skills possessed by individual attempting the task), transformers (variables that impact upon resources and determine the manner in which they are incorporated into output variables), and outputs. Existing models of group performance were shown to be special cases of the general model.

However, the model has limited capability for predicting group performance, in that it does not specify the ways in which resources and transformers interact to produce a product in a particular situation. In addition, it does not solve the problem of measuring resource and transformation variables. The model is most applicable to problem-solving and decision-making tasks.

Shriver, E.L., Henriksen, K.F., Jones, D.R., & Onoszko, P.W.J. Development of a leader training model and system (ARI Research Note 80-3). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1980.

The report described a preliminary theoretical model, that specified the nature and sequence of training for leaders (primarily Infantry squad and platoon leaders) in an engagement simulation environment. Engagement simulation exercises refer to field exercises which attempt to simulate combat conditions through real-time casuality assessment using such training aids as SCOPES, REALTRAIN and MILES. (See Section E1, ARI studies on REALTRAIN, for a more detailed description of such training procedures.)

The authors questioned the applicability of the instructional system development (ISD) model used by the Army to many combat arms training situations, particularly tactical operations where dynamic free-play exercises are common. The ISD model would require the identification in a task analytic fashion of all the critical conditions and actions involved in a combat engagement simulation mission. However, since conditions during such exercises are never the same even for two supposedly identical exercises, the ISD model with its emphasis on task analysis was considered inappropriate (p. 27).

The proposed training model identified three types of theoretical learning processes: experiential, analytic, and procedural. Each process reflected a well-established domain of psychological and instructional principles. The experiential process was defined as the "learning by doing" process, as reflected in engagement simulation exercises. Basic learning principles and benefits involved in such a process were: response-contingent reinforcement, response-contingent punishment, intrinsic motivation, learning by discovery, positive transfer of training, overlearning, latent learning, and problem-solving. The analytic process was defined as a cognitive-verbal process where experimental events are analyzed and explained, making significant events stand out, reaffirming what was learned, and identifying omissions or what was not learned. The after action review used in engagement simulation training reflects this type of learning. Basic learning principles and benefits involved in such a process were: focused feedback, peer learning, vicarious learning, understanding of assigned roles, understanding of overall gestalt (interrelated actions of individuals and groups that have a direct bearing on unit outcomes), verbal enunciation and transfer, and diagnosis of individual and unit training needs. The third process, procedural, was defined as learning how to perform any task that can be reduced to following a set of procedures. Such tasks are quite amenable to self-directed or individualized methods of instruction, and can be adapted to handle individual differences in skills. Basic learning principles and benefits characteristic of the procedural learning process were: individualized acquisition of skills, self-selection of skill modules, self-paced mastery, frequent feedback, active participation, manageable modular units, and two-way exchange of information with consultants.

The relationship between the three learning processes and the expected gains for developing major squad/platoon leader skills was then described. Five major leader skills were presented, based on a report by Henriksen et al., 1980 (see reference in Section B): management, communication, problem solving, tactical, and technical. In general, the experiential and analytic processes were predicted to provide the best learning environment for the first four skills; procedural processes were deemed as most appropriate for technical skills. Integration of these different types of learning conditions into a training system was also discussed. The authors felt that experiential learning such as engagement simulation should be conducted early since analytic and procedural learning may be more effective after a need for such learning has been demonstrated in a simulated context as opposed to

training under analytical and procedural conditions prior to experiential conditions. A study by Jones and Odom (1954, see reference in Section E3) was cited to support this proposition.

Siegel, A.I., & Miehle, W. Post-training performance criterion development and application: Extension of a prior personnel subsystem reliability determination technique (ONR contract, Nonr-2279(00)). Wayne, Pa.: Applied Psychological Services, June 1967. (DTIC No. AD 654 221)

The report presented a mathematical method for predicting the overall effectiveness of task performance as a function of performance quality, probability of success on each of the various activities in the task, elapsed time, and manpower requirements. Possible applications cited for these methods were: comparison of effectiveness of different teams or individuals who perform the same task, optimization of personnel assignments, derivation of training requirements, and evaluation of the design of new systems. Analyses presented were based on electronic maintenance tasks.

Siegel, A.I., Wolf, J.J., & Fischl, M.A. Digital simulation of the performance of intermediate size crews. I. Logic of a model for simulating crew psychosocial and performance variables. (Prepared for Office of Naval Research). Wayne, Pa.: Applied Psychological Services, September 1969. (DTIC No. AD 695 830)

A probabilistic computer model was developed to simulate closed man-machine systems operated by crews of 4 to 20 members. Selected physiological, psychological, and performance variables were discussed and then applied to crews. Such factors as the effects of fatigue and sleep, stress, group working pace, member competence, and member confidence in other team members upon group output were included in the model. No validation data for the model were presented.

Siegel, A.I., Wolf, J.J., & Consentino, J. Digital simulation of the performance of intermediate size crews: Application and validation of a model for crew simulation (Office of Naval Research contract N00014-68-C-0262). Wayne, Pa.: Applied Psychological Services, February 1971. (DTIC No. AD 720 354)

In a previous report, Siegel et al. (1969) described a stochastic computer model for intermediate size Naval crews. The model simulated characteristics of individual crew members, with each characteristic altered as a function of events that transpiredduring a simulated mission, and each characteristic in turn exerting an influence on mission events. Individual characteristics modeled includedphysical and mental performance, personality and motivational variables, learning and reinforcement, and aspiration and leadership.

The present report described revisions made to the model, sensitivity runs, and the results of validation runs. The validation runs were based on a four-day patrol boat mission in Viet Nam. Acceptable agreement between computer summaries and military interview summaries occurred with regard to

crew performance, percentage of events successfully completed, number of hours worked or slept, fatigue, the most logical skill speciality for an additional crew member, and the crew member least essential to the mission. Less agreement was found for the variables of crew competence, hours worked by type of personnel, physical workload, mental workload, and safety level.

Steiner, I.D. Models for inferring relationships between group size and potential group productivity. Behavioral Science, 1966, 11, 273-283.

The productivity of groups was conceived to be a function of three factors: task demands, resources, and process. Task demands are the requirements imposed on the group by the task or the rules under which the task must be performed. Resources include all the relevant knowledge, abilities, skills, or tools actually possessed by the individuals attempting to perform the task. Both of these factors can be determined prior to initiation of the task. Process consists of the actual steps taken by a group when confronted with a task.

The potential productivity of a group is the maximum level of productivity that can occur when a group uses its resources to meet the demands of the task. Actual productivity refers to what the group does in fact accomplish, and is viewed as being equal to or less than the potential productivity of the group. Problems of coordination and/or motivation (i.e., process factors) account for actual productivity being less than potential productivity. Thus actual productivity is defined as potential productivity minus both motivation and coordination losses.

The potential productivity of different types of task was examined. Mathematical formulas for additive tasks, conjunctive tasks, disjunctive tasks, compensatory tasks, and complementary tasks were presented.

Note. - Military teams usually perform complementary tasks (i.e., situations where a single individual performs only part of the total task, while other team members, who possess different kinds of resources, perform the remaining parts of the task).

Steiner, I.D. Group process and productivity. New York: Academic Press, 1972.

See reference in Section A. Steiner's theory of group productivity focuses on task demands, group resources, and group processes. Steiner specifies how these factors interact to influence group productivity.

Taylor, J.R. Modeling the task group as a partially self-programming communication net: A cybernetic approach to the study of social processes at the small group level. In K. Krippendorf (Ed.), Communication and control in society. New York: Gordon and Breach, 1979, pp. 407-421.

Taylor applied, in a very general way, some central concepts of cybernetic theory to small group functioning. For example, the

assumption of error correction or purposive regulation would "suggest that groups, presented with a problem, would vary their behavior until they had 'learned' an appropriate response, and would then stabilize around that pattern; that presentation of a new and more difficult problem would produce deviations from the previously learned patterns, and hence changes in group structure; that group perception of error will lead to changes of group process and structure; and that changes in process and structure will follow increases in information load" (p. 412). The concept of central integration of behavior implies an organization that can be flexibly altered by internal self-programming; that the total capacity of a group can be allocated in different ways, according to the task or the phase of the task involved. Taylor cited some small-group research that supported these cybernetic concepts.

Thibaut, J.W., & Kelley H.H. The social psychology of groups. New York: Wiley, 1959.

The primary focus of the book was on interpersonal relationships within groups (e.g., forming relationships within a group power, status, conformity to norms, group goals). In discussing the interdependence among individuals in large groups (p. 200-201), the authors noted that the coordination demands may be great. Coordination may not occur simply because there is a certain fixed probability that on a given occasion a group member will fail to coordinate. As the group size increases, there will be a corresponding increase in coordination failures. However, lack of coordination may also be accounted for by failure to pay attention, inability to make appropriate discriminations about the behavior of other group members, and failure to grasp the nature of group dependencies.

The authors concluded that since coordination problems increase with increase in group size, norms that specify the behaviors necessary for coordination are required. However, the time and effort required to achieve such norms also increases as group size increases. The authors noted that a major exception to the generalization that the greater the number of people in a group, the less likely they are to be able to synchronize their behavior, is when the actions of each person set-off a similar set of actions by the other members (termed snowballing).

Thibaut and Kelley identified three two-dimensional categories for classifying tasks (Chapter 9): steady vs. variable states, conjunctive vs. disjunctive tasks, and correspondence vs. noncorrespondence of task outcomes. The state of the task refers to the stimuli and situations presented to an individual which affects the way he performs the task; a steady state refers to the existence of a single state or situation. Correspondence of outcomes exists when the task requirements a group member must meet the requirements that must be met by other group members.

Tuckman, B.W. Developmental sequence in small groups. Psychological Bulletin, 1965 63, 384-399.

A model of group development was generated based on a review of therapy-group, T-group, and natural- and laboratory-group studies. Both the interpersonal stages of group development and the content of behaviors within the group were examined. A four-stage model was presented (p. 396) with the stages labelled forming, storming, norming, and performing. The forming stage focuses on orientation, and the establishment of dependency relationships with leaders, other members, and/or group standards. The storming stage is characterized by conflict and polarization around interpersonal issues and emotional involvement regarding group tasks. In the third stage of norming, ingroup feeling and cohesiveness develop, new standards emerge, and new roles are adopted. Finally in the performing stage, the group focuses upon accomplishing the task at hand since the group structure (member roles, interpersonal relationships) has been established. Tuckman acknowledged that the rate of group development will vary with the type of group, although limited data were available from existing studies to substantiate strong statements regarding such rate variations.

Zajonc, R.B. The requirements and design of a standard group task. Journal of Experimental Social Psychology, 1965, 1, 71-88. (DTIC No. AD 613 115).

The main focus of the article was on the development and standardization of a task(s) to be used in laboratory studies of small groups. Two points were made, however, that apply to all group/team studies. The first point was that "there simply is no consensus about the terms and units which denote and measure group responses" (p.72). The second point was that "group performance depends directly on two classes of factors: (a) the performance of individual members, and (b) the pattern of task assignments. All other variables affect group performance only through acting upon one or both of these primary classes of factors" (p. 73).

C. STUDIES EXAMINING VARIABLES THAT AFFECT TEAM PERFORMANCE

The articles in this section generally focus on experimental studies that examined the effect of certain variables upon team performance and therefore had a cause-effect purpose. In general, these variables were manipulated in the studies and could also be manipulated in training settings. Studies examining member ability, leader traits, and motivation variables are included in Section C2. Studies conducted with military teams are indicated with one asterisk in the classification list below; studies that attempted to simulate military settings are indicated by two asterisks; small group studies are not starred.

1. Performance Feedback/Evaluation

Berkowitz & Levy (1956)
Bowen & Siegel (1973)
Briggs & Johnston (1967)**
Eaton (1978)*
George, Hoak & Boutwell (1963)**
Horrocks, Krug & Heerman (1960)
Johnston & Howell (1966)**
Johnston & Nawrocki (1966)**
Marra (1971)
Nebeker, Dockstader & Vickers (1975)
Pritchard & Montagno (1978)
Torrance (1953)
Zajonc (1961)
AIR Studies (1962-1970)

2. Turnover in Group Members

Eaton & Neff (1978)*
Forgays & Levy (1957)*
Horrocks, Heerman & Krug (1961)
McDaniel & Dodd (1972)**
Miller (1971)
Morgan et al. (1978)
Trow (1964)
Ziller (1963)

3. Team Coordination/Cooperation

Banks et al. (1975)*
George, Hoak & Boutwell (1963)**
Hewitt, O'Brien & Hornik (1974)
Kabanoff & O'Brien (1979)
O'Brien & Owens (1969)

4. Characteristics of Tasks

Hackman (1968)
Hackman, Brousseau & Weiss (1976)
Hackman & Vidmar (1970)
Hackman, Weiss & Brousseau (1974)
Kabanoff & O'Brien (1979)
Kent & McGrath (1969)
Klingberg, Gonzales & Jones (1967)
Lord (1976)
Sorenson (1971)
Tuckman (1967)
Zajonc (1961)

5. Group/Team Size

Hackman & Vidmar (1970)
Havron & McGrath (1961)*
Kidd (1961)**
Kinkade & Kidd (1959)

6. Work Load and Work Structure/Distribution

Banks et al. (1975)*
Hallam & Stammers (1981)**
Johnston & Briggs (1968)
Kidd (1961)**
Kidd & Hooper (1959)**
Lanzetta & Roby (1956a, 1956b)**
Moore (1961)
Morgan et al. (1978)
Morrisette, Hornseth & Shellar (1975)
Roby & Lanzetta (1957a, 1957b)**

7. Communication Structure

George & Dudek (1974)
Guetzkow & Simon (1955)
Hallam & Stammers (1981)**
Kidd (1963)**
Kinkade & Kidd (1959)
Lanzetta & Roby (1956a)**
Leavitt (1951)
Moore (1961)
Morrissette, Hornseth & Shellar (1975)
Roby & Lanzetta (1957a)**
Williges, Johnston & Briggs (1966)

8. Group Planning/Orientation

Hackman, Brousseau & Weiss (1976)
Shure et al. (1962)

1. Variables That Can Be Manipulated

Banks, J.H., Hardy, G.D., Scott, T.D., & Jennings, J.W. Elements of a battalion integrated sensor system: Operator and team effectiveness (ARI Research Report 1187). Alexandria, VA.: U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Ord Field Unit, December 1975. (DTIC No. AD A025 911)

The effectiveness of ground surveillance radar and night vision devices at the company and battalion level was examined. The first part of the study examined the effectiveness of each device operating independently of the other. The second part of the study examined the effectiveness of a team composed of a team chief, radar operator (PPS-5A), and a Night Observation Device (NOD) operator.

The results from the first phase showed that no single device met all needs under realistic operational conditions. With the radar, target detection, timeliness of detection, and location accuracy were good, but target identification was poor. Just the opposite occurred with the NOD.

In the second phase of the study, three team configurations were compared. In the first team, the NOD and radar operators were co-located with the team chief, permitting direct voice communication within the team. In the second team, the NOD operator was physically separated from the co-located team chief and radar operator, requiring the NOD operator to communicate with the team chief by radio. The third team configuration was the same as the first except the team chief was provided a map on which to plot target information.

When a detection is made with one device, the typical military procedure is for the device operator to communicate such information to the team chief, the team chief in turn interrupts the free search of the other device operator, requesting him to verify the detection made by the first operator. Any losses in detection because of this process must be regarded as a cost of the system.

Findings from the second phase indicated no difference between the various team configurations with respect to percentage of targets detected by either the radar or the NOD, average distance traveled before the target was detected, and percentage of targets detected, handed off, and confirmed. Examination of individual device performance indicated that the number of detections obtained with the NOD increased in the team conditions, as compared to the independent search conditions in the first phase of the study. The team chief's coordination role was particularly important in all team configurations. The team chiefs participating in the study performed well, e.g., reported detection information in a timely manner, coordinated the search efforts of the two device operators, distinguished new from previously detected targets, etc. The team chief also reduced message volume to the battalion by consolidating detection reports. The authors concluded that a team using the radar and NOD devices with proper coordination and

employment procedures would obtain higher quality information than that provided by a single device or by the two devices used independently.

Berkowitz, L., & Levy, B.I. Pride in group performance and group-task motivation. Journal of Abnormal and Social Psychology, 1956, 53, 300-306.

The general purpose of the study was to examine the relationship between pride in group performance (manipulated by means of arbitrary performance evaluations) and task motivation. It was expected that groups "receiving favorable evaluations of the group as a whole would score higher on this motivation index than groups receiving unfavorable evaluations of the entire group or groups in which the members receive evaluations of solely their own performance" (p. 300).

The study design was a 2x2 factorial, with one factor being the type of evaluation given (high vs. low percentile rank feedback), and the other factor being the recipient of the evaluation (group as a whole or the individual). In addition, a control group that received no feedback was included. The subjects were high ability airmen; the task was an aerial interceptor air defense task with three-man teams. Each team had several practice trials, an initial test trial, a break, and a final test trial. Measures of task motivation were made during the break by categorizing member behavior into task-oriented discussion, non-task oriented discussion, and keeping to self behavior. In addition, a pride-in-group attitude scale was administered to all individuals.

Pride-in-group and amount of task-oriented discussion were greatest in groups receiving positive group evaluations. On the other hand, groups that received negative individual evaluations were low in group pride and high in "keeping to self" behaviors. The authors concluded that the relationship between group-task motivation and group pride "results from a perception of interdependence among the group members with respect to the attainment of reward" (p. 306).

Briggs, G.E., & Johnston, W.A. Team training (Technical Report: NAVTRADEVCEN 1327-4). Columuhus, Ohio: Ohio State University Human Performance Center, June 1967. (DTIC No. AD 660 019).

See reference in Section A. In Briggs and Johnston's review of their studies of simulated combat information centers, the importance of knowledge of results (KOR) was stressed. Their conclusions were presented in Section A and are repeated here.

a. KOR is particularly valuable in shaping behavior in those team tasks for which there is relatively little feedback intrinsic in the task itself. However, care must be exercised during training so that students do not become overly dependent on KOR which will not be present in operational tasks.

b. The use of individual-specific KOR (rather than total team KOR) is desirable especially in team tasks where it is not possible

for one man to compensate for the deficiencies of his teammate(s). This is especially true for relatively high-ability team members; however, low-ability team members can benefit equally from individual-specific or from total team KOR.

c. The specificity, detail, and quantity of KOR must be controlled rather carefully by the instructor. During initial training relatively gross aspects of individual performance are satisfactory and more detailed KOR simply cannot be used by the team members; indeed, they may misuse such information. During later stages of training detailed and more voluminous KOR may become invaluable for the "fine tuning" adjustments of highly skilled teams.

d. Teams will attempt to maximize those aspects of performance about which they receive specific and simple KOR even though other aspects of team performance may suffer in the process. In other words, teams will "do as they are told" by the instructor via KOR. Therefore, if several aspects of team performance are equally important, care must be exercised not to emphasize one to the detriment of the other aspects.

e. If teams experience a change in specific and simple KOR, they will readjust their performance rather rapidly to emphasize that aspect of performance about which they now are receiving KOR, even though this results in a deterioration of that aspect previously emphasized by KOR. However, if teams experience a change from specific and simple to more complex KOR (where two or more aspects of performance are given an equal weight), then they will continue to emphasize that aspect of team performance which previously was the subject of specific KOR while at the same time attempting to improve all aspects now being emphasized. Thus, an instructor must expect some conservatism in team performance as the complexity of KOR is increased, i.e., a team will "cling" to the more simple past as the complexity of the present KOR makes it more difficult for them to satisfy instructor demands.

Bowen, D.D., & Siegel, J.P. Process and performance: A longitudinal study of the reactions of small task groups to periodic performance feedback. Human Relations, 1973, 26, 433-448.

Periodic feedback in the form of grades, class rank, and instructor comments was given to four-person work groups at five three-week intervals throughout the length of a college course. Each work group was required to submit short literature reviews throughout the course; each paper counted as 15% of the entire grade; all members of the group received the same grade. Whenever the papers were submitted, a questionnaire was administered to each student to obtain his evaluation of (satisfaction with) his group's performance, satisfaction with his

role within the group, motivation for a high grade, and attractiveness of the group to him.

Results showed that ratings on each of these dimensions increased with time (i.e., became more satisfied with group performance, group became more attractive). In attempting to assess causal relationships among these dimensions, the authors concluded that the feedback of grades seemed to affect primarily the individual's satisfaction with group performance. Further causal sequences between the attitudinal and motivational variables could not be identified. The authors concluded that the process of group development as perceived by the individual supports the idea that a more favorable perception of the group and of the individual's role within the group evolves in conjunction with a higher level of motivation.

Eaton, N.K. <u>Performance motivation in armor training</u> (ARI Technical Paper 291). Alexandria, Va.: U.S. Army Research Institute for the Behavioral & Social Sciences, Ft. Knox Field Unit, September 1978. (DTIC No. AD A064 247)

Four types of rewards that could be used to motivate the performance of soldiers were examined. The four types were recognition (e.g., recognition from company commander for doing a good job), tangible rewards (e.g., getting a promotion in rank, a three-day pass), intrinsic rewards (e.g., feeling proud of doing a good job), and self-actualization (e.g., assigned to a more responsible position). Armor crewmen were asked to rank examples of each type in terms of the value of the reward and its perceived frequency of occurrence. A source motivation instrument was then developed based on the reward sources with the highest values and frequencies of occurrence.

In the second phase of the study, the source motivation instrument was given to tank crewmen ten weeks prior to and immediately before tank crew gunnery qualification. Relationships among motivation scores, and between motivation scores and crew gunnery performance were examined. For tank commanders, drivers, and loaders, performance was generally positively related to recognition-based motivation, and negatively to tangible reward motivation. For gunners, performance was negatively related to recognition-based rewards. The highest correlations between motivation sources and performance occurred for the tank commanders.

In the third phase of the study, the perceived value and frequency of the different types of rewards were found to be similar across rank (E2-E5). The authors suggested that motivation based on recognition would be easy to manage and would appear to be effective within the military.

Although the study focused on individual motivation and rewards, similar techniques could be investigated with team-level rewards.

Eaton, N.K. & Neff, J.F. The effects of tank crew turbulence on tank gunnery performance (ARI Technical Paper 350). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978.

The high turnover rates in tank crews that had been documented in previous reports indicated the need to examine the effects of such turbulence upon tank crew performance. Three types of crew turbulence were defined and examined: position familiarity (time to learn duty position), personnel familiarity (time individuals trained in specific duties had been assigned to a particular crew), and equipment familiarity (time crewmen had been assigned to a particular tank). It was expected that turbulence would have the strongest impact upon those crew members that interact with each other, specifically the tank commander (TC) and the gunner, as opposed to the loader and driver.

The first study examined the relationship between various indices of turbulence and tank gunner performance (hits and opening time per engagement) using tank crews from five armor battalions in US Army Europe. Weak, but significant, relationships in the expected direction were found between the time the TC and the gunner had trained together and crew gunnery performance. In addition, the TC's experience and the amount of gunner training correlated with crew gunnery performance.

The second study examined the effects of varying the position, equipment, and personnel familiarity of tank crews upon crew performance using tank crews in a FORSCOM unit. Four conditions were compared: existing armor tank crews (control); crews composed of members trained for specific positions as in the control group but interacting with different personnel and equipment (low personnel and equipment familiarity); crews with low personnel and equipment familiarity but also low in position familiarity (TCs were replaced by their gunners and gunner positions were filled by loaders, drivers and loaders had been trained for their respective positions); and crews composed of armor TCs and drivers but with nonarmor gunners and loaders who had been given three days of intensive training (teams low in equipment and personnel familiarity).

The major finding was that position familiarity (turbulence) had the greatest effect in reducing crew performances in terms of hits and opening engagement times (i.e., the lowest performance occurred with teams where the TCs were replaced by their gunners and gunner positions were filled by loaders). These differences were especially evident at night. The researchers cautioned that the gunnery tasks were quite structured and that personnel turbulence might have a greater impact upon unstructured than upon structured tasks.

Forgays, D.G., & Levy, B.I. Combat performance characteristics associated with changes in the membership of medium-bomber crews (AFPTRC-TN-57-140). San Antonio, Tex: Lackland Air Force Base, Air Force Personnel and Training Research Center, December 1957. (DTIC No. AD 146 414)

Two conflicting military concepts regarding turnover were discussed. The individual-interchangeability concept is based on the assumption that individual specialists can be changed from unit to unit without any appreciable decrement in the performance of the unit. On the other hand, the concept of crew integrity implies that a unit is a unique organization and will suffer in performance if membership changes occur. The authors stated that there was anecdotal evidence regarding both concepts, but few empirical tests of either.

Combat performance and rating data were obtained on 85 medium-bomber crews during the last months of active conflict in Korea. Changes in crew membership were recorded over a ten-month period, from the time each of the crews was assembled at Randolph Air Force Base until the data collection team contacted the crew in Japan or Okinawa in 1953. Each crew had spent up to three months in initial crew training and an additional four or more months in survival school, advanced crew training, etc. When the crews were contacted in the Far East, they had been in combat for approximately 6 to 25 weeks. During this entire period, the number of crew changes ranged from 1 to 11, with the average per crew being 4.2. Changes in officer positions accounted for 42% of the total; enlisted men, 58%. The officer positions of navigator, bombardier, and radar observer changed about the same number of times, approximately 30% more often than the typical enlisted-man position and about twice as often as the two pilot positions. For purposes of analysis, the crews were divided into three groups according to the number of membership changes: 1-2, 3-4, and 5-11 changes. This breakdown yielded three groups of approximately equal size.

Criterion measures were divided into four categories: rating data (6 scores including ratings by superior officer, crew ratings by crew members), administrative overhead (sick call frequency, percent assigned missions not successfully completed), performance scores (average circular error of each crew's combat bomb drops, average time error made by crew in arriving at control points during combat missions), and three crew attitude measures (sense of well-being, coinfidence in superior officers, and motivation to have an effective crew).

Although a negative monotonic function was expected, i.e., as number of changes increased the performance measures and ratings would decrease, the more typical relationship was curvilinear. The 3-4 change group showed the highest level of performance and the 5-11 change group tended to show the lowest level. Additional data analyses during the initial crew training period and during the advanced crew training/combat tour period showed similar findings. It should be noted that the findings were partially affected by the statistical procedures applied. For example, if the researchers had dichotomized the crews into 1-4 vs.

5-11 crew changes (i.e., a simple low vs. high change), then the data would have supported the hypothesis that turnover has a detrimental effect upon crew performance.

George, C.E., & Dudek, R.A. Performance, recovery and man-machine effectiveness: Final report on a basic research program under project THEMIS (Prepared for Army Human Engineering Laboratory). Lubbock, Tex.: Texas Tech University, April 1978. (DTIC No. AD 777 707)

This document includes short summaries of the studies conducted under Project THEMIS. One study examined the role of verbal communication in crew training. Results showed that performance was lower when verbal communication was limited in the early stages of training than when verbal communication was allowed. The researchers concluded that even when crews are being trained to work in situations that allow "little or no verbal communication, it is important to allow verbal communication in the early stages of training in order to facilitate learning in the use of non-verbal cues" (p. 29).

George, C.E., Hoak, G.R., & Boutwell, J. Pilot studies of team effectiveness (Research Memorandum No. 23). Ft. Benning, Ga.: U.S. Army Infantry Human Research Unit, Human Resources Research Office, February 1963. (DTIC No. AD 627 218)

A series of four exploratory studies was conducted that examined the effectiveness of laboratory-created five-men teams to solve four types of problems. Coordination among team members was varied by manipulating the extent to which members had to respond for other members, the amount of feedback that team members had to provide to other members in order for the team to solve the problem, and the level of team task motivation that characterized the central man in the team.

Team cohesion was also examined in some of the studies. The need for examining intrateam coordination was based on the assumption that effective Infantry teams must continually respond both to environmental cues and to what other team members are doing. Participants were Army enlisted men. The team task motivation scale (i.e., a measure of the extent to which an individual is reinforced by being a member of an effective team) was in its developmental stage in these studies.

Major results and conclusions were: (a) higher performances occurred when the bulk of the team's strength was entrusted to three of the five team members as opposed to only two members or distributed equally among all members (implication: when forming small teams from large pools of men, spread out the least competent individuals so that no one team has more than its proportionate share), (b) when the key man on a team was high on team task motivation, the team performed more effectively than when he was low, the level of task motivation for the entire team increased as did the level of team cohesion, and (c) feedback from team members can aid the performance of other members who

are responding from "blind" positions (this finding has implications for Infantry night operations).

The authors also concluded that effective groups are not necessarily similar to each other, particularly when the groups have been in existence for a period of time. Thus generalization from ad hoc to experimentally created, short-lived groups to real-life existing groups may be difficult.

Two major hypotheses were developed. One, coordinate response behavior (what one person must do to make maximum contributions to task resolution depends upon what other members are doing) becomes habitual in effective teams, that response coordination is learned by trial-and-error when team members are individually competent in their roles, and that it becomes habitual when members are task-oriented because the resultant improvement in team performance is reinforcing to such persons. It is desirable to learn how to manipulate tasks and instructions so that the coordinate response habit is established in team members early in their team history. Two, teams are better able to handle stress by having the most pressure-resistant members in central or key positions and by gradually increasing task difficulty over training trials.

Guetzkow, H. & Simon, H.A. The impact of certain communication nets upon organization and performance in task-oriented groups. <u>Management Science</u>, 1955, <u>1</u>, 233-259.

The authors argued that previous studies on communication nets/patterns by Leavitt (1951) failed to distinguish between the effects of communication restrictions upon performance and the effects of communication restrictions upon the ability of the group to organize appropriately. Prior analyses indicated that minimum performance times should be the same for various communication nets if the groups employed the optimal organizational pattern. Comparison of three five-man group communication nets, all-channel, wheel, and circle, supported this hypothesis. Another outcome was that certain communication nets created more organizational problems than others, thus lengthening the time to achieve efficient task performance. The authors concluded that it is inappropriate to assume a one-to-one relationship between effective functioning and freedom in communication; in some cases such freedom inhibits performance.

Hackman, J.R. Effects of task characteristics on group products. <u>Journal of Experimental Social Psychology</u>, 1968, <u>4</u>, 162-187.

Hackman's main thesis is that small-group research is affected by the nature of the tasks used by groups, yet very little attention has been paid to the nature of the task. The task should not be treated as merely "something for the group to do." Instances where discrepancies in research findings were due to the nature of the task were cited. The continued use of idiosyncratic tasks in small-group research makes it difficult to generalize across studies.

Hackman examined three types of "intellective" tasks: tasks calling for production of ideas, images, or arrangements; tasks calling for discussion of values or issues; and tasks requiring a solution to a specific problem (problem-solving). In addition, tasks of each type were divided into three difficulty levels, and groups were exposed to four tasks within each type-difficulty combination. A total of 108 different groups worked on 108 different tasks. Six general dimensions served as the primary dependent measures (action orientation, originality, issue involvement, length, optimism, and quality of presentation). Task type accounted for up to 50% of the variance on the dependent measures, indicating the important role of the nature of the task in affecting group performance. Difficulty and interactions between difficulty and task type accounted for up to only 7% of the criterion variance.

Discriminant analyses led the author to refine his definition of task types. The original classification was based upon task content (i.e., issues, images/ideas, and overt actions). Another dimension, process emphasis, was introduced: presentation, evaluation, and instruction. Thus production tasks were redefined as involving the presentation of ideas or images; discussion tasks as involving the evaluation of issues, and problem-solving tasks as involving instruction with respect to over actions.

Hackman, J.R., Brousseau, K.R., & Weiss, J.A. The interaction of task design and group performance strategies in determining group effectiveness. Organizational Behavior and Human Performance, 1976, 16, 350-365.

Three intervention strategies which affected the manner in which a group approached a task were compared: instructions that fostered overt discussion of task performance strategies; instructions that inhibited strategy discussion (get to work, don't spend time on preliminary discussions of the task); and a control where instructions were given to the group. Two task conditions were also investigated: one where every group member received the same information about the task (equal information) and one where group members were given unequal information about the task. The task required assembly of small electrical components. Observations of group processes and self-report measures were also made.

As hypothesized, little discussion of performance strategies occurred within the control group. When the appropriate performance strategy was not obvious to all members and coordination was required for effective performance (unequal task condition), the discussion strategy resulted in higher performance than instructions to inhibit strategy discussion. When the appropriate performance strategy was obvious and straight forward (equal task condition), instructions inhibiting strategy discussion resulted in higher performance than instructions to discuss strategy. Strategy discussion appeared to consume time that could have been used for productive work in such

situations. Questionnaire results suggested that the strategy groups encountered more task and interpersonal problems than the other groups, but were more flexible.

Hackman, J.R., & Vidmar, N. Effects of size and task type on group performance and member reactions. Sociometry, 1970, 33, 37-52. (DTIC No. AD 706 820)

The effects of group size (2 through 7 members) and task characteristics on group performance and member reactions to the group process were studied. Three types of intellectual tasks were examined: production/presentation of ideas, discussion/evaluation of issues, and problem solving tasks requiring resolution of a course of action. Twelve tasks of each type were examined and the study was replicated at two different institutions. Several measures of group performance and of member reactions were obtained. Size affected only member reactions, with dyads being the most satisfied, and type of task affected both group performance and member reaction measures. The three types of tasks had different effects on the various performance measures and on the member reaction measures as well.

Although the tasks examined are typical of small group research rather than team research, the results do reinforce the need to examine the type of task and its effect upon various performance criteria.

Hackman, J.R., Weiss, J.A., & Brousseau, K.R. Effects of task performance strategies on group performance effectiveness (Prepared for Office of Naval Research). New Haven, Conn.: Yale University, October 1974. (DTIC No. AD A001 707)

A small group (four-man) assembly task was examined under two task conditions: in one condition each member was provided with all task-relevant information, and in the other condition task-relevant information was unequally spread among group members. Within each of these tasks conditions, three performance strategies were compared: instructions to discuss how to approach the task, instructions to void discussing how to approach the task and to immediately begin work, and a control condition where no instructional strategy was given. The quantity and quality of the components produced were examined, observations of group interaction were made, and member reactions to the group process were obtained.

When members had all task-relevant information, output was greatest in the condition where discussion of performance strategies was discouraged. On the other hand, when members had unequal amounts of task-relevant information, output was the greatest in the condition where discussion of performance strategies was encouraged. Control groups produced the lowest amount of output, regardless of the distribution of task information.

Observations of the interaction process verified the experimental strategy treatments. Authors noted that much pretesting was required

before an appropriate intervention strategy was found; and that until a procedure is developed for differentiating among group tasks and determining the moderating functions of such tasks, it will be almost impossible to develop appropriate strategies for improving group effectiveness. In addition, advances in observation techniques must be made in order to document changes in group interaction over time and describe the aspects of interaction critical to group output.

Hallam, J., & Stammers, R.B. The effects of task characteristics on the organization of the team. In R.C. Sugarman (Ed.). Proceedings of the Human Factors Society 25th Annual Meeting. Santa Monica, Calif.: Human Factors Society, 1981, p. 546-550.

A series of experiments examined the effects of input load and complexity of task upon two-man teams performing simulated command and control tasks. Teams were organized in either a vertical (serial) or horizontal (parallel) team organization. Input load was varied by the rate of input presentation and the number of trackers to be monitored. Complexity was varied by introducing the requirement for a periodic status report and by using tracks that crossed between the sectors of the two operators.

Results indicated that a vertical team organization was inappropriate when input and complexity were high. The first vertical operator became overloaded, while the second operator, whose inputs were the outputs from the first, was underloaded. However, performance of horizontally organized teams decreased when interaction was required between the two operators. The authors concluded that a necessary condition for the effective operation of horizontally organized teams is that the operators distribute their efforts appropriately among the different tasks to be performed.

Havron, M.D. & McGrath, J.E. The contribution of the leader to the effectiveness of small military groups. In L. Petrullo & B.M. Bass (Eds.), Leadership and interpersonal behavior. New York: Holt Rinehart & Winston, 1961, p. 167-178.

The authors discussed a series of studies conducted on the Infantry squad, and focused, in particular, upon the characteristics of the squad leader that were related to squad effectiveness. Squad effectiveness was measured by small-scale standardized field maneuvers of six to eight hours continuous duration.

Squad leader characteristics that best predicted unit effectiveness were measures of leader job knowledge and leader intelligence ($r = .35$ to $.50$), and the degree to which the leader knew his men ($r = .70$). Measures of the leader's emotional stability, leader's attitude toward military life, and the extent to which the leader was perceived by the squad members as being close to their ideal-leader also predicted unit effectiveness.

Among the least-effective squads, neither the leaders nor the members were motivated or responsive to their environment. Within the most-effective squads, strong differences in personalities, direction of drive, and concepts of leadership occurred. However, these squads were alike in that they gave more thought to how to solve their problems than did the other squads. Squads where members felt free to give orders to another when the situation seemed to warrant such action performed better than squads in which only the leader gave orders.

In one study of squad training, teamwork was stressed, i.e., lives of squad members are interdependent, the careless mistake of one man can lead to disaster for the entire group. The program stressed the importance of the leadership function, regardless of the personality or capabilities of the leader, and that more than one type of leadership could be effective. Squads exposed to the training program exceeded all squads in the control group, who had been through the regular Army program, on a test that measured squad effectiveness without the squad leader.

Another series of studies investigated the optimal size for the Infantry squad (four, five, six, seven, eight and eleven man units). In the difficult tactical missions, squad leaders of the large units maintained unit effectiveness at a great cost (higher activity level, more leader exposure to the enemy). The eleven-man squad with one leader controlling ten men was simply too large. With squads from four to eight men the six-man squad performed best.

Hewett, T.T., O'Brien, G.E. & Hornik, J. The effects of work organization, leadership style, and member compatibility upon the productivity of small groups working on a manipulative task. Organizational Behavior and Human Performance, 1974, 11, 283-301. (DTIC No. AD A001 268)

Two forms of work organization or cooperation were examined: collaboration, which occurs when some of the positions within a group share joint responsibility for certain tasks; and coordination, which occurs when subtasks allocated to different positions need to be sequenced. Four variations of cooperation were examined: no collaboration and no coordination, collaboration with no coordination, coordination with no collaboration, and collaboration and coordination. The degrees of collaboration and coordination required by the task were measured by a procedure developed earlier by O'Brien. In addition, leadership style and member compability were examined. The task was a relatively simple, model building task. The major result of the study was that collaboration greatly hindered task performance.

The results contrasted with prior research on creative tasks, where the coordination-collaboration condition facilitated performance. The authors inferred that this particular combination, in the present study, had actually made an easy job difficult by creating organizational difficulties where group members got in each other's way. A clear implication of the study was that having groups of similar people perform the same task does not guarantee comparability of findings across groups. The way in which group members are organized to complete the task must be considered as well.

Horrocks, J.E., Heermann, E., & Krug, R.E. Team training III: An approach to optimum methods and procedures (Technical Report NAVTRADEVCEN 198-3). Columbus, Ohio: Ohio State University, August 1961. (DTIC No. AD 267 666)

The report described the final series of studies on team training conducted for the Navy on "Navy-like" decoding tasks performed by Navy teams. Three studies were conducted, but only the first two examined team training. The third focused on maximizing individual skills.

The first study examined the effect of change in group membership on team performance and found no facilitative effect of constant group membership as compared to complete and partial changes in group membership. The second study examined the extent to which working together as a team on one task would transfer positively to another task. No facilitative team effect occurred.

Note. – The particular tasks used did not require much team or group effort, that is, the tasks could be completed by only one person and the nature of communication (verbal and nonverbal) among team members was greatly restricted.

Horrocks, J.E., Krug, R.E., & Heermann, E. Team training II: Individual learning and team performance (Technical Report: NAVTRADEVCEN 198-2). Columbus, Ohio: Ohio State University, Research Foundation, August 1960. (DTIC No. AD 247 147)

Two laboratory tasks were created which were intended to be representative of tasks performed by Navy teams. Team was defined as a "task-oriented organization of individuals interacting to achieve a specified goal." The first task was primarily a decoding task performed by five-man teams under one of three training (rehearsal) conditions: individual, subteam, and team. Knowledge of results was compared to no knowledge of results, and some pretraining was given to subteams who performed similar jobs. The second task was primarily a preceptual-estimation task using four-man teams. Four variations in the amount of feedback were compared. Results showed no difference in the three training conditions (individual, subteam, team), no facilitation by kind of pre-training given in the study, and some facilitation by knowledge of results. The authors indicated that since team proficiency can be developed through individual and subteam practice and such training is probably less costly than team training, it should be stressed.

Note. – In the introduction the authors stated they assumed that team "coordination is the natural outcome of a sequence of properly planned and executed individual acts." The tasks they created stressed the individual. Successful completion of the tasks required each person to complete his job and hand-off his product to the next person in the chain. Two-way communication was limited and actually impossible in some situations. Thus the amount of coordination among team members was limited.

Johnston, W.A., & Briggs, G.E. Team performance as a function of team arrangement and work load. Journal of Applied Psychology, 1968, 52, 89-94.

Radar control two-man teams performed a simulated approach control task, with controllers alternating in directing incoming aircraft. High and low load conditions (rate of incoming aircraft) were compared, as well as compensatory and noncompensatory conditions. In the compensatory condition, one individual could compensate for his partner's early or late approaches. In the noncompensatory conditions, the approach had to be maintained for each aircraft. It was expected that the opportunity for compensatory activity should be an inverse function of system load, since the higher the load the less time a team member has to compensate for his partner's errors. Fail-stop behavior (where a team member prevents his partner from committing an error) should, however, be directly related to load on the system, since error frequency should be higher under high load conditions. It was expected that individuals in the compensatory condition would pay more attention to their partner's behavior and therefore be more likely to prevent partner errors. Although team communication has sometimes been found to inhibit team performance, it was expected that this inhibitory function should be less under team load since team members cannot afford the luxury of high levels of communication under such conditions.

Results showed that the average approach times were closer to criterion in compensatory teams than in noncompensatory teams, particularly under low load conditions. Under high load conditions, fewer flight errors occurred in compensatory teams than in noncompensatory teams. Team communication inhibited team performance only in the noncompensatory high load condition.

Johnston, W.A., & Howell, W.C. The effect of team feedback on individual performance and self-evaluation (Final Report, Grant No. AF-AFOSR-985-66). Columbus, Ohio: Ohio State University, Human Performance Center, September 1966. (DTIC No. AD 640 804)

Individuals performed a tracking task, but each was told that he had a partner. Team feedback was then simulated by telling the subject that the feedback reflected his performance relative to the average performance of both team members. In reality, feedback represented the subject's individual tracking performance relative to various difficulty criteria that were varied experimentally. Therefore, a stringent or difficult criterion produced poor feedback, as though the subject had a poor partner, and a lenient criterion simulated a good partner.

Over the series of studies conducted, subjects generally performed best with "good" partners. In addition, subjects accepted the credit for good team scores, but attributed the blame for poor scores to their contrived partners. Results supported the hypothesis that team feedback influences individual behavior within a small group.

Johnston, W.A., & Nawrocki, L.H. The effect of simulated team feedback on the performance of good and poor trackers (Technical Report: AFOSR-66-2541). Columbus, Ohio: Ohio State University, Human Performance Center, November 1966. (DTIC No. AD 644 430)

This is a more detailed test report of the Johnston and Howell report cited above.

Kabanoff, B. & O'Brien, G.E. The effects of task type and cooperation upon group products and performance. Organizational Behavior and Human Performance, 1979, 23, 163-181.

The effects of three types of intellectual tasks (discussion, problem solving, and production), and two forms of cooperation (collaboration and coordination) upon various characteristics of group products (written reports) and the quality of those products were examined. The classification of tasks was based upon Hackman's work, and the distinction between coordination and collaboration was based on earlier work by O'Brien (collaboration occurs when some group positions share joint responsibility for certain tasks; coordination reflects the extent to which subtasks allocated to different positions are sequenced by definite precedence relations). Groups were composed of three individuals of the same sex.

Strong effects were found for the task type and cooperative dimensions. Task type accounted for up to 50% of the variance on the descriptive dimensions (e.g., length, optimism, issue involvement), but had little effect on the evaluative dimensions (e.g., adequacy, quality, and creativity). Group structure accounted for 22 to 36% of the variance on both the descriptive and evaluation measures. In groups where collaboration was required, the products were rated lower on each of the three evaluative dimensions than in groups where collaboration was not required. On the other hand, coordination requirements led to higher ratings on each of these dimensions. One of the major conclusions was that collaboration was relatively ineffective for tasks that require evaluation of multiple, perhaps competing solutions, at least when no single correct solution can be specified. The different effects of collaboration and coordination point to the need for more sophisticated understanding of the concept of cooperation than is usually presented (p. 179).

Kent, R.N., & McGrath, J.E. Task and group characteristics as factors influencing group performance. Journal of Experimental Social Psychology, 1969, 5, 429-440.

The authors replicated Hackman's (1968) work on the effects of task type on the characteristics of written group products, finding that task type (production, discussion, problem solving tasks) had a strong influence on group output, accounting for over 50% of the variance on three dimensions and about 20% of the variance on four additional dimensions. The authors also included the variable of sex composition of the group in the design (homogeneous and heterogeneous groups). Sex

composition did have an effect on task output, but the effect was not as strong as the task type factor.

Kidd, J.S. A comparison of one-, two-, and three-man work units under various conditions of work load. <u>Journal of Applied Psychology</u>, 1961, <u>45</u>, 195-200.

Kidd reviewed studies that have found that if a single person can do a task under moderate load conditions, the addition of one or two helpers does not result in a doubling or tripling of the input load capability. A relatively complex air traffic control task was simulated in the present study. Under the one-man condition, one individual was responsible for all aircraft; under the two-man condition, the zone of responsibility was divided equally among the two individuals; three men had equal responsibility for aircraft in the three-man condition. Results showed that "when input load to the system was held constant and the control unit size was increased, leading to a decrease in load per controller, performance was upgraded only moderately. When input load to the system was increased proportionately to the increase in team size, resulting in a constant load per controller across conditions, performance was markedly diminished in the multiman units" (p. 199). Kidd concluded that maximum performance can be attained when coordination demands are minimized in such tasks.

Kidd, J.S. Work team effectiveness as a function of mechanical degradation of the intrateam communication system. <u>Journal of Engineering Psychology</u>, 1963, <u>2</u>, 1-18.

The third experiment in this report examined the effects of different degrees of unintelligibility within the communication network of a simulated air traffic control system. Communications were interrupted (cut-off) for various lengths of time. A second part of the study examined techniques that might reduce the degradation created by such interruptions.

The first part of the study showed that performance was degraded in direct relationship to degree of intermittency within the communication network. The most effective "remedial" technique was that where the controller maintained a near-continuous message flow; he repeated a message until its receipt was acknowledged.

Kidd, J.S., & Hooper, J.J. <u>Division of responsibility between two controllers and load balancing flexibility in a radar approach control team: A study in human engineering aspects of radar air traffic control</u> (WADC Technical Report 58-472). Columbus, Ohio: Ohio State University, Laboratory of Aviation Psychology, April 1959. (DTIC No. AD 214 616)

The performance of two-man radar approach control teams was evaluated under three methods of aircraft assignment and two levels of restraint on the option of exchanging control responsibility during the approach. All aircraft conditions were simulated. The three aircraft

assignment methods were: sector control where assignment was made on the basis of location of entry; rotation control where equal load was ensured by assignment on the basis of simple alternation; and destination control where aircraft bound for one of the two available landing fields were always asigned to the same controller regardless of time or place of entry into the terminal area. The two control restraint conditions were: partial where control of aircraft could be exchanged only after the first 20 miles of the approach had been traversed, and no restraint where exchange of control responsibility could be made at any time during the approach. Each team of controllers participated twice under each of the experimental conditions.

Destination assignment and maximum freedom to transfer control resulted in the highest performance in terms of system efficiency (e.g., flight time, fuel consumption) and safety (separation errors between aircraft). In addition, team members preferred the destination method and the flexibility allowed by the absence of exchange restraints. Crew members indicated difficulty in coordination, when coordination was required. Although communication between crew members was low, when communication occurred it was task-oriented.

The superiority of the destination assignment condition was explained by the researchers as providing a balance between task demands and coordination demands. The last phase of the approach is the most critical. In the other conditions, controller responsibility did not correlate with aircraft location. Therefore, aircraft under one man's control could cross the path of aircraft under the other's control or be close to that path. Thus both coordination and task demands were placed upon operators in these conditions, while only task demands occurred in the destination condition.

Kinkade, R.G., & Kidd, J.S. The effect of team size and intermember communication on decision-making performance (WADC Technical Report 58-474). Wright-Patterson Air Force Base, Ohio: AERO Medical Laboratory, April 1959. (DTIC No. AD 215 621)

The performance of single individuals, two-man teams without intercommunication, and two-man teams with intercommunication was compared on a checkerboard decision-making task. Mean time required to complete the task was lower for the two-man teams than for single individuals. However, group productivity was not a linear function of the size of the group (i.e., the two-man teams were not twice as productive as single individuals). There were no differences among the three treatments on two other criteria: errors and average number of tokens moved through the goal per minute.

Klingberg, C.L., Gonzales, R.K., & Jones, W.H. Effects of work pacing and teaming on interpreter performance. Seattle, Wash.: Boeing Co., 1967. (DTIC No. AD [illegible])

The second phase of the study compared series and parallel team structures using image interpretation problems. Participants in the

study were experienced photointerpreters, participating in two-man interpreter teams. In reality, only series teams were directly examined, with the second member of the team responsible for insuring that all targets in the photo had been found and for verifying the accuracy of his partner's responses. Scores for series team data were based on the final modifications made by the second member of the team. Parallel team data were based on the series team data, with scores based on all responses made by the two interpreters and also on only those responses for which there was agreement by both interpreters.

The highest degree of accuracy was obtained with parallel teams, when only targets reported by the two independent interpreters were scored, but the completeness of the responses was reduced, i.e., some targets were missed. The authors concluded that if both accuracy and completeness are required, two-man series teams provided the best compromise. An additional finding, based on the parallel team data, was that inventive errors committed by one member of the team were not duplicated by the other members. The authors concluded that interpreter teaming appeared to be most valuable with difficult tasks, when the skills of individual members are quite different, or when accuracy is of high priority.

Lanzetta, J.T., & Roby, T.B. Effects of work-group structure and certain task variables on group performance. Journal of Abnormal and Social Psychology, 1956, 53, 307-314. (a)

The primary variables investigated in this study were the nature of information transmission within a team and the rate of change of input to the team. Three-man bomber crews were simulated. The basic task required crews to process instrument readings, relay necessary information to individuals requiring it, and execute control adjustments based on relayed or directly available instrument readings. Two information transmission structures were examined: high autonomy where each subject had two controls for which all but one of the requisite instrument readings was available in his individual booth, and low autonomy where each subject had two controls for which none of the four necessary instrument readings was directly available.

Crew errors increased as rate of input increased. The most difficult information transmission structure was that in which a large proportion of information had to be relayed, and particularly, where a large proportion of information had to be relayed from several different sources. The authors hypothesized that the transmission structure findings may be the result of two factors: the volume of information to be relayed and the extent of dispersion of relevant information.

The authors concluded that "the limiting factor in the performance of the groups was not their gross information capacity. Rather, the difficulty seemed to lie in the inability of groups to set up an efficient system for detecting and communicating information changes. Communication problems may result from ignorance on the part of response agents as to when information bearing on their controls enters the group

at some other station, and on the part of information-source persons as to the relevance of new information they receive. Detection difficulties may be a function of a response conflict generated by placing the individual in the dual role of response agent and information source" (p. 313).

Lanzetta, J.T., & Roby, T.B. Group performance as a function of work-distribution patterns and task load. Sociometry, 1956, 19, 95-104. (b)

Two types of work-distribution patterns were compared: a vertical structure where different homogeneous functional categories were assigned to each individual of the team (i.e., information processing or decision-making), and a horizontal structure, where the total task was divided into subtasks, with subtasks assigned to each individual (all functions may be required within each subtask). Thus the main focus of the study was to investigate the effects of specialization of functions among members versus nonspecialization.

The task presented to each three-man team was based on an Air Defense command aircraft control and warning center where three target areas were identified and the task of the teams was to intercept enemy aircraft attempting to bomb the target areas. Within this context, the vertical structure functions consisted of observation, calculation, and decision-making, while under the horizontal structure each member was responsible for defending one of the three target areas and thereby employing all functions. In addition to the two types of work-distribution patterns, two task-load conditions were examined. The high-load condition involved more enemy and friendly planes than was the case for the low-load condition. Each team was exposed to both structure conditions, under one level of task load. Order of presentation was counterbalanced. Team performance was based on scoring the number of times the target areas were bombed, the number of enemy bombers downed, the number of interceptors lost, and the number of friendly planes accidentally downed.

Significant effects occurred for load (high-load conditions resulting in poorer performance than low-load), and a load by session effect (high-load performance increased with time, while low-load performance decreased). Although structure effects were of most interest to the researchers, they did not occur. However, the authors stressed a tendency for the horizontal structure to be superior to the vertical structure under low load conditions.

As pointed out by the authors, the task presented in the study differed from many others in small group research in that no one person could solve the problem; distribution of task functions and/or of subtasks among team members was essential.

Leavitt, H.J. Some effects of certain communication patterns on group performance. Journal of Abnormal and Social Psychology, 1951, 46, 38-50.

Leavitt examined four types of communication patterns within five-man groups: circle, chain, Y, and wheel. The research results (e.g., time to solution, errors, number of messages, member satisfaction) and the communication concepts developed in this study (e.g., centrality and peripherality indices) and similar studies appear to have the most applicability to military teams when the communication pattern within a military team approximates a pattern studied in the laboratory.

Lord, R.G. Group performance as a function of leadership behavior and task structure: Toward an explanatory theory. Organizational Behavior and Human Performance, 1976, 17, 76-96.

The influence of differences in task structure upon the amount or type of leadership behaviors required for successful group performance was investigated. In particular, the leader's role in orienting the group and in defining the problem for the group was studied. Task structure reflected the clarity, verifiability, and number of goals, and the number of paths to the goals. Lord viewed high structure tasks and leadership orientation as both providing the group members with a "common problem space", i.e., similar encoding of key aspects of the problem confronting the group. Therefore, it was hypothesized that leadership orientation and task structure would be inversely related since they both have similar effects on group performance (i.e., high degrees of leadership orientation are not needed in high structure situations). In addition, it was hypothesized that the relationship between performance and leadership orientation would be inversely related to task structure (i.e., for tasks with high structure the relationship would be low, for tasks with little structure the relationship would be high).

Tasks used in the study were based on Shaw's work, and were scaled in terms of task structure on Shaw's dimensions of decision verifiability, goal clarity, goal path multiplicity, and solution multiplicity. Leadership orientation scores were based on observations of group problem solving and included such behaviors as diagnosis or interpreting situations or problems, describing tasks or problems, identifying relevant variables/constraints/goals, introducing new ideas or focusing attention, and summarizing events.

The relationship between task structure and leader orientation behaviors was significant, in the hypothesized direction, but the percentage of variance explained was low (1? - 20%). The results did not support the second hypothesis. Instead a curvilinear relationship was found; the relationship between orientation and performance was positive for moderately structured tasks, and negative for both low and high structured tasks. Lord explained the negative relationship for low structured tasks as follows: the particular tasks studied had multiple and unverifiable solutions; although individuals worked as members of a

group each individual could come up with his own solution; the group was willing to accept most reasons due to the unverifiable nature of the solution; thus with these tasks divergent "problem spaces" probably facilitated task performance.

Note. - Lord's interpretation of the results reinforces the need for an analytic approach to studying group tasks in order to determine the critical factors that affect group performance.

Marro, H.A. <u>A comparative analysis of group reinforcement contingencies.</u> San Francisco, Calif.: Letterman Army Institute of Research, U.S. Army Medical Research and Development Command, September 1971. (NTIS No. AD 732 954)

Three types of group reinforcement procedures were compared: independent, where each individual in the group was reinforced only when he was correct; interdependent, where each individual was reinforced only when members within the group were correct; and double - reinforcement where each individual was reinforced when he was correct as well as when the entire group was correct. The general hypothesis was that group members under the double-reinforcement system would perform better than individuals under either of the other two systems. The interdependent condition was expected to produce the lowest number of correct individual responses. The data supported the hypotheses. In addition, the double-reinforcement system resulted in increased performance over time, whereas minimum improvement was shown under the other two conditions. No data were presented on the number of correct team responses.

Although the task was a laboratory reaction time task using three-man groups composed of high school students, the three conditions examined do represent actual variations in reinforcement that can be received by military teams: reinforce the group as a whole after the task is completed, provide individual reinforcement as each individual performs his task, or use both procedures. The data support using both procedures to maximize performance.

McDaniel, W.T., & Dodd, J.R. <u>Minuteman combat crew integrity: Its effect on job satisfaction and job performance.</u> (Master's thesis). Wright-Patterson Air Force Base, Ohio: Air University, September 1972. (DTIC No. AD 750 950)

The relationship of turnover in Minuteman combat crews (two-man) to job satisfaction and job performance was examined. However, due to the Air Force's policy of maintaining integral crews, there was limited variation in crew turbulence. Results showed that crew integrity was a source of job dissatisfaction for some of the crews and had no significant effect on job performance (simulated).

Miller, D.T. Skill dilution and skill level requirements as determinants of crew performance. Doctoral Dissertation, Texas Tech University, 1971. (DTIC No. 738 182)

The major hypothesis of the study was that the amount of skill dilution occurring within a team is related to the task centrality of the member being replaced; specifically, that the replacement of members more central to the task should result in more skill dilution and poorer group performance. Two-man teams, organized as a chain, performed a perceptual motor task that required matchng responses to various stimulus patterns. No differences in team performance were found as the result of member replacement.

Moore, H.G. The effects of load and accessibility of information upon performance of small teams (AFOSR-1676). Ann Arbor, Mich.: University of Michigan, October 1961. (DTIC No. AD 268 462)

Two-man teams were created to perform the dispatching, bookkeeping, and monitoring functions of a simulated taxi control system. One individual's responsibility was to assign cabs to passengers; the other's responsibility was to monitor the positions of the cabs, to start them on their runs, and keep records. Two independent variables were examined: input load (rate at which passenger requests were received by the team, labeled high and low), and access to information (limited vs free: access to communicating with and seeing each team member, observing the electronic timers for each cab and the experimenter). Team effectiveness was based on a score which reflected penalties for delays, costs per mile and per passenger, and bookkeeping errors.

Based on previous research it was hypothesized that increased access to information would enhance team performance under conditions of low load but would have detrimental effects under conditions of high load. Instead, increased access to information had an enhancing effect in the high load condition. The improved performance of the higher load teams under free access to information apparently resulted from more effective and flexible load balancing procedures and "other acts of collaboration in performing routine functions, enabling the work to be done more rapidly and cabs to be assigned more quickly to waiting passengers. This was accomplished without an increase in bookkeeping errors or any loss in the efficiency of assignments. Also, under free access to information teams were able to perform better in the experimental session, minimizing waiting time without sacrificing accuracy, indicating a more rapid adoption of an effective team organization for getting work done." (p. 69-70).

Morgan, B.B., Coates, G.D., Alluisi, E.A., & Kirby, R.H. The team-training load as a parameter of effectiveness for collective training in units (ITR-78-14, prepared for U.S. Army Research Institute for the Behavioral and Social Sciences). Norfolk, Va.: Old Dominion University, May 1978. (DTIC No. AD A063 135)

The performance of five-man teams working for eight hours per day over six consecutive days on a multiple-task performance battery was examined. Subtasks consisted of several individual tasks (watchkeeping, arithmetic problems, and target identification), and one team task (a code-lock task). Subjects were asked to perform these tasks under various work-load combinations, that is, the tasks were presented according to low, medium, and high demand performance schedules during each two-hour period of testing.

The primary variable investigated in the study was called team-training load and referred to the percentage of untrained members on a team. Eleven team-training loads ranging from 0 to 100 percent untrained members in 10 percent steps were represented. The major findings and conclusions were (p. 30-31):

> Team performance was degraded in direct proportion to the team-training load, i.e., the percentage of untrained members of the team. Such degradation was due to the untrained members, not to the trained members.
>
> The untrained team members tended to acquire individual skills at the same rate, independent of team-training load. Therefore teams with high team-training loads initially suffered greater decrements in performance, but recovered in the same training time as teams with lower team-training loads.
>
> In general, these results applied to both individual and team measures, except that team-skills were more resistant to decrements with the lower team-training loads (below 40% untrained) and more seriously affected by higher team-training loads (above 40% untrained).

The authors cautioned that these findings should be verified with field tasks. However, if the results were replicated, then the implications for military training, considering personnel turnover, were as follows (p. 31):

> If fewer than 10 percent of a team/crew members are untrained, then the best strategy would be to assign untrained persons uniformly throughout so as to minimize the proportion of untrained personnel in any one team/crew. If the personnel turnover is greater than 40%, then the best strategy (and probably the most cost-effective) would be to assign maximum numbers of untrained members to certain teams and to schedule those teams for earlier team-training missions, even at the expense of postponing the

training of teams/crews that have been maintained with fully trained personnel, some of whom have been transferred from teams/crews that are assigned high percentages of untrained individuals.

Morrissette, J.O., Hornseth, J.P., & Shellar, K. Team organization and monitoring performance. *Human Factors*, 1975, *17*, 296-300.

Four monitoring conditions were examined: one individual monitored four displays, two individuals each monitored two of the four displays, a two-man team where each individual monitored four displays (redundancy), and a two-man team where each individual monitored two of the four displays (division of labor). The longest detection times occurred under the individual condition, with no significant differences in average detection time among the remaining conditions. Further analyses of the team conditions showed that the faster of the two members was faster only 70% of the time with the slow member contributing to lower the team time 30% of the time. Comparison of the detection time distributions for the two team conditions indicated that the redundant team organization eliminated very long detection times, thereby reducing response variability.

Nebeker, D.M., Dockstader, S.L., & Vickers, R.R. *A comparison of the effects of individual and team performance feedback upon subsequent performance* (NPRDC TR 75-35). San Diego, Calif.: Navy Personnel Research and Development Center, May 1975. (NTIS No. AD A010 131)

The effects of different types of individual and team feedback upon individuals performing an additive team task (i.e., team performance is the sum of individual member's performance) was examined. Each feedback variable had three levels: no feedback, raw score feedback, and percentile feedback. In addition, a control group was added, individuals who performed the task as an individual rather than as a team member, and who received one of the three levels of individual feedback. The task was a perceptual motor card sorting task. The number of cards sorted per individual was the dependent variable. Four five-minute trials were administered.

Only the individual feedack variations had a significant effect upon performance, with the no feedback condition resulting in low performance. However, the results have minimal relevance for military teams due to the limited coordination required by the task. The authors speculated that team feedback would have greater effects when tasks demanded greater member coordination.

O'Brien, G.E. & Owens, A.G. *Effects of organizational structure upon correlation between member abilities and group productivity* (Technical Report No. 25 (69-4), Prepared for Office of Naval Research). Urbana, Ill.: University of Illinois, Department of Psychology, Group Effectiveness Research Laboratory, June 1969. (DTIC No. AD 692 407)

The contribution of member ability to group productivity was found to vary with whether a task required collaboration or coordination. With collaborative tasks, group members are expected to cooperate with each other at all stages of task activity, as in discussion and problem-solving tasks. With coordination tasks, different subtasks are allocated to different positions and the subtasks are then ordered by definite precedence relationships. Thus all members not only have an opportunity to influence the group product but are required to contribute to it. As expected, on coordination tasks group performance was positively related to the summed abilities of all group members as well as to the ability of the least competent member. Such relationships did not occur on the collaborative tasks. These findings were replicated in two studies. Mathematical formulas for quantifying the degrees of collaboration and coordination for different tasks were also presented.

Pritchard, R.D., & Montagno, R.V. Effects of specific vs. nonspecific and absolute vs. comparative feedback on performance and satisfaction (AFHRL-TR-78-12). West Lafayette, Ind.: Purdue Research Foundation, May 1978. (DTIC No. AD A005 693)

Although the report focused on individual rather than group feedback, the authors presented a preliminary taxonomy of feedback dimensions that can be applied to groups or to individuals. Fourteen dimensions (not necessarily unrelated) were identified:

Positive vs. negative
Timing of feedback
Specificity
Evaluative - nonevaluative
Absolute - comparative
Internal - external
Personal - impersonal
Power of source
Schedule of feedback
Degree of relevance to individual performance
Comprehensiveness
Formal - informal
Public - private
Accuracy

Fourteen factors that can influence intrinsic motivation were also identified:

Feelings of personal control over the task
Feelings of competence at doing the task
Contingent extrinsic rewards (negatively related)
Degree of variety in the skills required to do the task
Degree to which the task requires the use of valued abilities
Degree to which the person identifies with the task
Degree to which the person does a complete unit of the task
Perceived significance of the task

Degree of autonomy on the task
Adequacy of performance feedback
Higher order need strength
Work values
Cultural influences
Optimal arousal level

A study was conducted that examined the influence of specific vs. nonspecific and absolute vs. relative feedback upon individual performance. Results indicated different effects with different types of feedback. Contrary to expectations, nonspecific feedback resulted in higher performance than specific feedback, although this may have occurred because of subjects' low involvement in the task. Comparative feedback tended to be superior to absolute feedback. Feedback, irrespective of type, was superior to no feedback. A good discussion of the possible mechanisms used to explain how feedback works was presented.

Roby, T.B. & Lanzetta, J.T. A replication study of work group structure and task performance. Lackland Air Force Base, Tex.: Air Force Personnel and Training Research Center, June 1957. (a) (DTIC No. AD 134 205)

Four types of communication/information systems were established within three-man work groups on a simulated aircraft instrument task. Each individual could only communicate with the other members of the group by telephone. The four information structures compared were as follows: (a) members had access to none of the information required to operate their own controls and had to obtain four units of information from other group members, (b) members had direct access to one unit of information and required three units from other group members, (c) members had direct access to two units of information and required two units from other members, and (d) members had direct access to three units of information and required one unit of information from other members. The proportion of information directly accessible to each member was related to performance measures (i.e., high amounts of directly accessible information were associated with fewer errors and faster learning times.)

Roby, T.B., & Lanzetta, J.T. Conflicting principles in man-machine system design. Journal of Applied Psychology, 1957, 41(3), 170-178. (b)

Two conflicting organization principles governing the effectiveness of man-machine systems were examined. The autonomy principle states that the optimal arrangement of displays and controls is one in which each person who needs certain types of information for making control actions is also the primary source of that information, and if information must be relayed to a control it should be relayed from a single source rather than from several sources. On the other hand, the load balancing principle states that the total work of the team should

be distributed as evenly as possible. The study compared three team structures that varied in autonomy and load balancing.

Three-man bomber crews were simulated. Degrees of autonomy and load balancing were experimentally varied by manipulating the number of instruments observed by each individual, the number of controls for which each individual was responsible, and the number of communication links between the user and the source of information. In addition, the rate at which information was fed to individuals was varied.

When autonomy was controlled, those teams organized according to the load-balancing principle made fewer errors. When load-balancing was controlled, those teams organized according to the autonomy principle made fewer errors. Rate of input also influenced the number of errors, with high input rates producing more errors. The authors concluded that an over-loaded individual is as likely to neglect obligations to other group members, thereby increasing their errors, as he is to neglect his own control responsibilities. The groups studied were unable to adapt fully to increased load on the individual or the entire group. The burden of initiating communications was placed on the user of the information rather than the immediate source, resulting in a loss of much relevant information.

Shure, G.H., Rogers, M.S., Larsen, I.M., & Tassone, J. Group planning and task effectiveness. Sociometry, 1962, 25, 263-282.

Three group conditions that allowed for different opportunities for group planning were compared on task efficiency, organizational development, and message interaction. In one group there was no opportunity for the group to plan how to solve the task; in the second condition planning could occur only during the period of task completion; in the third planning occurred between periods of task completion. Five-man groups were exposed to 20 trials of a problem-solving task commonly used in communication structure studies. Each member obtained a card stating which one of six geometric symbols he was missing for that trial. Each subject's missing symbol differed from the others in the group, leaving only one symbol common to all members. The group task was to have all members report to the common symbol. The common symbol was randomly distributed across the twenty trials. The all-channel communication network was used, so that each member could send and receive messages directly from every other group member.

In the non-planning condition, none of the groups achieved a stable communication organization and task efficiency was lowest of all three conditions. In the separate planning condition, a large number of extra-task planning messages were exchanged, and a hierarchical organization was implemented rather early which stabilized with time. Improvement in task efficiency paralleled the emergence and stability of this organizational structure. In the condition where planning and task accomplishment occurred simultaneously, very few of the groups established organizational structures for communication, and few devoted time to exchanging information regarding organization. Task efficiency was low for this condition. Lack of time spent in planning was attributed to the pressure to complete the task and to the immediate reinforcing value of task completion, despite the subject's awareness of the long-term utility of cooperative planning.

Sorenson, J.R. Task demands, group interaction and group performance. Sociometry, 1971, 34, 483-495.

The relationship of input, process, and output variables within three-man problem-solving groups was examined using two types of intellectual tasks (Hackman's distinction between production or creativity tasks and problem-solving tasks), five measures of group behavior during the task (structuring, generating, elaborating, evaluating, and requesting), and two output measures (product quality and originality). Differences were found between the two types of tasks on four of the five measures of group behavior and on the output measure of product quality. However, relationships between group behavior and output measures were not systematically related to task type. In some cases, group behaviors positively related to product quality on a specific task were negatively related to product originality on the same task. Research to date has focused primarily on the influence of task type upon group processes. The author recommended that more research be

conducted regarding the influence of required task outputs upon group processes.

Torrance, E.P. Methods of conducting critiques of group problem-solving performance. Journal of Applied Psychology, 1953, 37, 304-308. (b) (DTIC No. AD 004 178)

Four different techniques for conducting critiques of group problem-solving performance (debriefings) were compared. The four techniques were labelled as: unstructured non-authoritarian critique, directive or expert critique, structured non-authoritarian critique, and self-critique. A control group that had no critique was included as well. The expert critique and structured non-authoritarian critique groups showed the greatest improvement in problem-solving scores. Performance in the two unstructured techiniques did not differ from that in the control group.

Trow, D.B. Teamwork under turnover and succession (Technical Report No. 2, Office of Naval Research contract Nonr 3679 (00), Project NR 170-231). Endicott, NY: Harpur College, June 1964. (DTIC No. AD 601 816)

Four-man groups performing a team-type task experienced different types of membership replacement. The task required team members, through a set of electric pushbutton switches and in communication with each other by intercom, to type coherently on a single typewriter. Information and communication constraints were imposed, so that no single individual could complete the task. Team performance was found to suffer when replacements were made in key, rather than subordinate positions, and when the replacement's level of intelligence was lower than that of his predecessors's. The author cautioned that in other instances team performance might also be lowered when turnover occurs in subordinate positions.

Tuckman, B.W. Group composition and group performance on structured and unstructured tasks. Journal of Experimental Social Psychology, 1967, 3, 25-40.

The purpose of the study was to determine whether group performance is influenced by the interaction of group member composition/traits with task demands rather than by group composition alone. Two tasks were compared: a structured sonar tracking task and an unstructured land navigation task. Three-man groups exposed to this problem differed in terms of the ability of individual members to handle abstract situations and on the personality trait of dominance. As predicted, groups having a majority of individuals high on abstractness performed better on the abstract task than groups composed of a majority of individuals who were low on abstractness (high on concreteness). No performance differences occurred on the structured task.

Williges, R.C., Johnston, W.A., & Briggs, G.E. Role of verbal communication in teamwork. Journal of Applied Psychology, 1966, 50, 473-478.

A simulated radar-controlled aerial intercept task was used to examine two conditions of verbal communication within two-man teams: a condition where verbal communication was necessary since visual coordination was not possible, and a condition where both verbal and visual coordination could occur. It was hypothesized that the verbal only condition would foster "good" communication skills which would then transfer to the verbal-visual condition.

Team coordination was found to be better in the verbal-visual condition than in the verbal condition, across both the learning and transfer time periods. Content analysis of the verbal communications between the two radar controllers indicated that verbal condition produced more declarative statements (communications conveying information redundant with display information and originally obtainable only by viewing the display), while the verbal-visual condition produced more tactical statements and commands (communication conveying task-relevant information not directly obtainable from the display and requests for action issued by one radar controller to his partner), irrespective of the learning and transfer time periods. Thus the hypothesis was not supported.

The authors concluded that verbal communication facilitates performance only when a more efficient information channel is not available.

Zajonc, R.B. The effects of feedback and group task difficulty on individual and group performance (Technical Report No. 15, Prepared for Office of Naval Research). Ann Arbor, Mich.: Institute for Social Research, University of Michigan, November 1961. (DTIC No. AD 269 580)

Two group feedback conditions were compared: direct feedback where feedback was given to each team member about his performance, the performance of other members, and the group as a whole; and confounded feedback where only information about the performance of the group as a whole was presented. Two levels of task difficulty were presented within each feedback condition: an easy task where successful performance was required of only one member of the group, and a difficult task where successful performance was required of all seven group members. The task was a reaction time task. The direct feedback condition resulted in higher group and individual performance than the confounded feedback condition, and greater improvement occurred in the difficult than the easy task condition.

Ziller, R.C. The effects of changes in group composition on group performance. Final report (Grant No. AFOSR 62-95). Newark, Del.: University of Delaware, 1963. (DTIC No. AD 412 965)

Ziller summarized three studies examining a group's acceptance of a newcomer, and the effects of turnover on group performance. The turnover study involved two-man groups. Results showed that turnover in groups created the greatest decrease in performance when members in the position with the greatest control over the task were changed.

American Institutes for Research Studies on Team Training

Klaus, D.J., & Glaser, R. Increasing team proficiency through training. 8. Final summary report (AIR-E1-6/68-FR). Pittsburgh, Pa.: American Institutes for Research, May 1968. (DTIC No. AD 669 638)

Klaus, D.J., & Glaser, R. Reinforcement determinants of team proficiency. Organizational Behavior and Human Performance, 1970, 5, 33-67. (DTIC No. AD 708 382)

During the 1960s, a series of studies on the effects of various conditions of team reinforcement on team proficiency was conducted by the American Institutes for Research and sponsored by the Office of Naval Research. The two reports just cited summarize these efforts, and the studies cited below provide greater detail on each study. The following summary describes the team situation used throughout these studies and the major purpose and results of each study.

Throughout the studies teams were viewed as a single response unit whose behavior/output/performance could be modified by using procedures similar to those used to modify individual responses. The primary focus of the studies was upon the use of team reinforcement. Analyses of the reinforcement contingencies available to individual members as a result of team reinforcement were made. The nature of the team task (e.g., serial, parallel) created different reinforcement contingencies for individual team members and consequently led to different predictions regarding team proficiency.

In most of the studies three-man teams performed a serial task, where individual members responded to different light patterns for either two or four seconds. These responses could vary slightly around the two- or four-second criterion, but the small amount of error allowed made complete mastery of the skill almost impossible. Within the three-man team two individuals monitored the light patterns, and the third individual determined whether the two monitors made two- to four-second responses with a two- to four-second response period himself. Usually reinforcement was given only when all three members performed correctly, i.e., team reinforcement only. Team members could not see each other during the trials. All were males from local high schools and were paid for their participation in the study. Pretraining was given to all participants until a pre-determined level of individual proficiency was acquired. Team proficiency was typically acquired within

60 trials (one trial was defined as a five-minute period) or five days. In some cases, however, as many as 60 experimental sessions spread over several months were required.

The first study focused upon whether team responses could be acquired and extinguished by the processes of reinforcement and nonreinforcement Details on this study can be found in the following references:

Glaser, R., Klaus, D.J., & Egerman, K. Increasing team proficiency though training. 2. The acquisition and extinction of a team response (AIR-B68-5/62-TR). Pittsburgh, Pa.: American Institute for Research, May 1962. (DTIC No. AD 276 429)

Glaser, R. & Klaus, D.J. A reinforcement analysis of group performance. Psychological Monographs: General and Applied, 1966, 80 (13, Whole No. 621). (DTIC No. AD 640 624)

Five operant conditioning situations were examined in the following order: response acquisition (reinforcement), response extinction (no reinforcement), spontaneous recovery, response re-acquisition, and response re-extinction. Team performance curves were similar to those obtained with individuals under similar reinforcement conditions. In some cases, acquisition of the team response was slow, due to the low rate of reinforcement associated with the requirement that every team member had to respond correctly before team reinforcement was given.

The second study focused on the effects of including a redundant team member, and was reported in the following papers:

Egerman, K., Klaus, D.J., & Glaser, R. Decremental effects of reinforcement in teams with redundant members. Paper presented at the annual meeting of the American Psychological Association, September 1961. (DTIC No. AD 262 742).

Egerman, K., Klaus, D.J., & Glaser, R. Increasing team proficiency through training. 3. Decremental effects of reinforcement in teams with redundant members (AIR-B68-6/62-TR). Pittsburgh Pa.: American Institute for Research, June 1962. (DTIC No. AD 276 428).

Glaser, R. & Klaus, D.J. A reinforcement analysis of group performance. Psychological Monographs: General and Applied, 1966, 80 (13, Whole No. 621). (DTIC No. AD 640 624)

Glaser, R., & Klaus, D.J. Studies of the reinforcement components of group performance. From a symposium on the simulation of human behavior. Paris, July 1967. (DTIC No. AD 702 587).

The team/task arrangement was varied in this study so that the two monitors operated in parallel with each other and in serial with the third operator. Thus only one of the monitors, along with the operator, had to perform correctly. When one monitor performed correctly, the

other monitor's performance was redundant. In such situations, an individual monitor could be reinforced even though he performed incorrectly. Having a redundant member was expected to lead to an initial increase in team performance, but such inappropriate reinforcement was expected to eventually lead to an increase in incorrect performance by either or both of the monitors over time and thus to a decrease in team performance. The shape of this learning curve, however, was expected to vary with the proficiency of the two monitors. In general, the predicted early increases and later decrements in team performance did occur.

The third study expanded upon the second study by examining three types of two-man teams: a series team, a parallel team, and an "individual" team (team performance depended upon only one pre-selected member). Details of the study are found in the following two documents:

Egerman, K., Glaser, R. & Klaus, D.J. Increasing team proficiency through training. 4. A learning-theorectic analysis of the effects of team arrangement on team performance. (AIR-B64-9/63-TR). Pittsburgh, Pa.: American Institute for Research, September 1963. (DTIC No. AD 422 329).

Egerman, K. Effects of team arrangement on team performance: A learning-theoretic analysis. Journal of Personality and Social Psychology, 1965, 3, 541-550. (DTIC No. AD 635-700)

Within the three types of teams investigated in this study, four feedback linkages between team output and team members response were defined: appropriate reinforcement where team reinforcement followed correct individual performance, appropriate nonreinforcement where no team reinforcement followed an incorrect individual response, inappropriate nonreinforcement where no team reinforcement followed a correct individual response, and inappropriate reinforcement where team reinforcement followed incorrect individual performance. It was possible to order the schedules of reinforcement for the different teams from most to least favorable: continuous reinforcement for correct performance (preselected members of the individual team arrangement); aperiodic reinforcement for correct performance (members with series task); continuous reinforcement for correct performance but aperiodic reinforcement for incorrect performance (parallel team members); and aperiodic reinforcement for both correct and incorrect performance (partners in the individual team condition). Research hypotheses that specified that series team performance would improve over time and that the performance of parallel teams and partners within the individual team would decrease over time, due to the reinforcement schedule administered to each member, were supported.

The fourth study in the series varied the proficiency of team members performing in series and is documented in the following report:

Klaus, D.J., & Glaser, R. Increasing team proficiency through training. 5. Team learning as a function of member learning characteristics and practice conditions (AIR-E1-4/65-TR). Pittsburgh, Pa.: American Institutes for Research, May 1965. (DTIC No. AD 471 460).

Three levels of team proficiency were established based upon proficiency of members achieved at the end of individual pretraining. In addition, two levels of learning ability were examined based on the speed with which individual proficiency was acquired during pretraining. Only two of the six low proficiency teams reached the team acquisition criterion, and these successful teams required more trials than was the case for the medium and high proficiency teams. High teams were more resistant to extinction than medium proficiency teams. Teams composed of fast learners required more trials to reach criterion than teams composed of slow learners. This result was explained as resulting from the lack of experience these individuals had had with the low ratios of reinforcement characteristic of early team practice.

The fifth study examined the effects of supplementary individual reinforcement within the team context. A complete report can be found in:

Klaus, D.J., Grant, L.D., & Glaser, R. Increasing team proficiency through training. 6. Supervisory furnished reinforcement in team training (AIR-E1-5/65-TR). Pittsburgh, Pa.: American Institutes for Research, May 1965. (DTIC No. AD 471 470)

Three-man teams operated in parallel, with each member serving the role of a monitor. Members of half the teams received supplementary individual reinforcement in initial team response acquisition; the other teams did not. Such feedback continued until the team acquisition criterion was reached, feedback was then terminated, and the team was again required to reach the acquisition criterion without supplementary individual reinforcement. Supplementary individual reinforcement led to more rapid development of team proficiency than was the case for the teams without such reinforcement, but no positive carry-over effects occurred when the teams were required to reach proficiency without this added feedback.

The final study in the series examined the possibility of simulating team training conditions using only one subject. This phase focused on reducing the detrimental effects of the low reinforcement ratios that occurred early in the team acquisition process. Details can be found in:

Short, J.G., Cotton, T.S., & Klaus, D.J. Increasing team proficiency through training. 7. The simulation of team environments (AIR-E1-6/68-TR). Pittsburgh, Pa.: American Institutes for Research, May 1968. (DTIC No. AD 669 687)

C. STUDIES EXAMINING VARIABLES THAT AFFECT TEAM PERFORMANCE

2. Variables That Are Not Easily Manipulated

In general, the studies cited here focused on cause-effect relationships. However, the variables of interest are not as easily manipulated in field studies as is the case with the variables in Section C1. Again, military studies are indicated with one asterisk in the classification list below; laboratory simulations of military settings with two asterisks.

1. Leader Characteristics

Bons & Fiedler (1975)*
Clark (1960)*
Fiedler & Meuwese (1962)*
Havron & McGrath (1961)*
Lord (1976)
Mitchell (1970)
Schwartz (1963)*
Shaw & Blum (1966)
Ziller, Behringer & Hawkins (1962)*

2. Member Abilities

Gill (1979)
Jones (1974)
Klaus & Glaser (1965)
Laughlin & Johnson (1966)
O'Brien & Owens (1969)
Terborg, Castore & DeNinno (1975)
Trow (1964)
Tuckman (1967)**

3. Group Aspiration

George, Hook & Boutwell (1963)*
Morrissette et al. (1967)
Zander (1970)

4. Member Attitudes

Terborg, Castore & DeNinno (1975)

Bons, P.M., & Fiedler, F.E. The effect of changes in command environment on the behavior of relationship- and task-motivated leaders (TR 75-63). Seattle, Wash.: University of Washington, January 1975. (DTIC No. AD A021 495).

The study examined the effect of job rotation, changes in superior, and/or changes in subordinates on the behavior and performance of 115 Infantry squad leaders tested at the beginning of their training cycle and six to nine months later. The major conclusions were as follows (p. 28):

a. Leaders who had aspects of their job change perceived their situation as less favorable than those leaders who remained in the same job environment.

b. Task-relevant behaviors by the leaders seemed more strongly affected by changes in the leader's environment than were person-related behaviors. However, a change in the total job environment tended to

affect person-related variables as far as the leader's subordinates were concerned and task-related behaviors as far as the leaders' superiors were concerned.

c. Leader experience emerged as an important factor. Leaders who were experienced and therefore used to change seemed less affected by job changes than less experienced leaders. Subordinates perceived fewer differences between experienced and inexperienced leaders than did the leaders' superiors.

Clark, R.A. Developing a functional theory of leadership. In Collected papers prepared under work unit INTERSQUAD: A study of the factors which account for the differences between effective and ineffective rifle squads. (HumRRO Professional Paper 7-69). Washington, D.C.: George Washington University, Human Resources Research Office, March 1969, pp. 25-31. (b) (DTIC No. AD 686 621)

Five leadership functions of Infantry rifle squad leaders were identified: managing the squad, defining rules and procedures for acceptable behavior, performing as a model, teaching squad members, and sustaining squad members with emotional support. Of the 69 squads studied, the managing and defining functions were most likely to be performed by the squad leader himself. The modeling, teaching, and sustaining roles occurred less frequently and were likely to be performed by the squad leader, assistant squad leaders, or other squad leaders. Summary data indicated a relationship between the performance of these functions and the effectiveness of the squad.

A theory of functional leadership was postulated whereby the five leadership functions were viewed as the means by which squad leaders initiate and develop group values such as group cohesion, group loyalty, group goals, and acceptance of combat aggressiveness. These values, in turn, determine what the squad "can do and will do" (i.e., its combat effectiveness).

Fiedler, F.E., & Meuwese, W.A.T. The leader's contribution to performance in cohesive and uncohesive task groups (Office of Naval Research Contract Nonr-1834(36), NR 177-472). Urbana, Ill.: University of Illinois, Department of Psychology, April 1962. (DTIC No. AD 720 420)

The authors performed secondary analyses on previously conducted studies to test the hypothesis that a leader's ability will correlate positively with the performance effectiveness of cohesive groups, but not of uncohesive groups. The authors assumed that if a leader is to have a direct influence on the group's effectiveness, the group's structure must allow him to communicate effectively with all members and the members must be willing to follow his orders. Results from several studies on tank crews, B-29 bomber crews, and anti-aircraft artillery crews supported the hypothesis. It was suggested that leaders in uncohesive groups must exert their efforts on maintaining the group; while such maintenance activities are not required in cohesive groups.

Therefore, leaders of cohesive groups can focus their efforts on solving the group's problems, and in turn, influence the quality of group task performance.

George, C.E., Hoak, G.R., & Boutwell, J. Pilot studies of team effectiveness (Rsearch Memorandum No. 28). Ft. Benning, Ga.: U.S. Army Infantry Human Research Unit, Human Resources Research Office, February 1963. (DTIC No. AD 627 214)

See reference in Section C1. The level of team task motivation was examined. A major finding was that when the key man on a team was high on team task motivation, the team performed more effectively than when he was low, and the level of task motivation for the entire team increased as well.

Gill, D.L. The prediction of group motor performance from individual member abilities. Journal of Motor Behavior, 1979, 11(2), 113-122.

The performance of two-person groups with different average ability levels and homogeneous vs. heterogeneous ability composition were compared on a motor maze task. Both collaborative and noncollaborative versions of the task were examined. With each version, the average ability level of the group predicted group performance. In addition, group performance on both tasks, but particularly the highly cooperative task, was dominated by the lower-ability partner. Apparently the higher-ability partner could not compensate for the other partner's poorer preformance. The author predicted that the ability-composition/group-performance relationship is likely to be even lower in natural settings due to the limited reliability of group performance measures and extraneous factors that create variability in group performance.

Havron, M.D. & McGrath, J.E. The contribution of the leader to the effectiveness of small military groups. In L. Petrullo & B.M. Bass (Eds.), Leadership and interpersonal behavior. New York: Holt Rinehart & Winston, 1961, pp. 167-178.

See reference in Section C1. Correlates of infantry squad effectiveness were leader intelligence, emotional stability of the leader, leader's attitude toward military life, and squad member motivation and drive.

Jones, M.B. Regressing group on individual effectiveness. Organizational Behavior and Human Performance, 1974, 11, 426-451.

Measures of individual (or subgroup) effectiveness were used to predict success of teams in four professional sports: football, baseball, tennis, and basketball. Individual measures of tennis skills were used to predict success in doubles play, performance of the defensive and offensive football squads were used to predict overall team success, performance of baseball pitching staffs and the remaining team members were used to predict baseball success, and the individual

skills of each member of the basketball teams were used to predict team success. For each sport a high linear relationship was found between individual or subteam skill and overall team performance (tennis, R = .75; football, R = .91; baseball, R = .93; basketball, R = .58). Although the relationships are strong in each case, it should be noted that where individual performances rather than subteam performances were used as predictors, the relationship was lower (tennis doubles and basketball), indicating that factors other than individual skill per se also contributed to overall team performance.

Klaus, D.J., & Glaser, R. Increasing team proficiency through training. 5. Team learning as a function of member learning characteristics and practice conditions. (AIR-E1-4/65-TR). Pittsburgh, Pa.: American Institutes for Research, May 1965. (DTIC No. AD 471 469).

See reference in Section C1 (AIR studies). Two levels of learning ability of group members were examined. The performance of teams composed of high ability members decreased at a slower rate during periods when reinforcement was withdrawn than was the case for teams composed of lower ability members.

Laughlin, P.R., & Johnson, H.H. Group and individual performance on a complementary task as a function of initial ability level. Journal of Experimental Social Psychology, 1966, 2, 407-414.

Complementary tasks were defined as those where each member performs only the parts of the total task for which he possesses the necessary skills. It is assumed that each individual has some resources/skills that are unshared by other members of the group and are necessary for task completion. The combination of these unshared resources within the group should result in higher performance levels than those achieved by the same individuals working independently.

When the complementary task confronting a group involves general ability, then it is predicted that a person working with a partner of greater or comparable ability will improve relative to his performance alone, while a person working with a partner of less ability will not improve relative to his performance alone. This prediction was supported by the study results.

Lord, R.G. Group performance as a function of leadership behavior and task structure: Toward an explanatory theory. Organizational Behavior and Human Performance, 1976, 17, 76-96.

See reference in Section C1. Lord examined the interaction between the leader's tendency to direct/orient the group and the degree of task structure upon group performance.

Mitchell, T.R. Cognitive complexity and group performance. Seattle, Wash.: University of Washington, Department of Psychology, 1970. (NTIS No. AD 766 901)

The performance of three-man groups with high cognitive complexity leaders was better than that of groups with low complexity leaders. Two problem-solving tasks and two group discussion tasks were examined. Leader behavior, as perceived by both group members and leaders, tended to vary with the group task. The behavior of high complexity leaders was more variable than that of the low complexity leaders, changing as the group atmosphere changed. The author cautioned against generalizing the results to other types of tasks.

Morrissette, J.O., Jahnke, J.C., Baker, K. & Rohrman, N. Degree of structural balance and group effectiveness. Organizational Behavior and Human Performance, 1967, 2, 383-393.

The degree of structural balance within three-man problem-solving groups was manipulated by giving group members bogus information regarding the relative willingness of individuals to cooperate within the group. Two group conditions were established, one with high structural balance and one with a lower level of balance. It was hypothesized that group tension would be inversely related to the degree of structural balance (high tension associated with low balance) and that group performance would be directly related to the degree of structural balance. It was also expected that groups with low structural balance would spend relatively more time on maintenance activities (e.g., resolving interpersonal conflicts, procedural matters) than would groups with high balance, and that high balance groups would spend more time on achieving group goals than would low balance groups.

In general, the predictions were supported by the data. The differences between the structural groups in effectiveness and in perceived and actual times devoted to group goals relative to maintenance functions were replicated when the structural groups were each divided into high and low tension groups.

O'Brien, G.E. & Owens, A.G. Effects of organizational structure upon correlations between member abilities and group productivity (Technical Report No. 75 (69-4), Prepared for Office of Naval Research). Urbana, Ill.: University of Illinois, Department of Psychology, Group Effectiveness Research Laboratory, June 1969. (DTIC No. AD 692 407)

See reference in Section C1. The interaction between member ability and collaboration/coordination type tasks was examined.

Schwartz, S. Tank crew effectiveness in relation to the supervisory behavior of the tank commander (HumRRO Technical Report 68-12). Alexandria, Va.: Human Resources Research Office, September 1968. (DTIC No. AD 679 918)

The relationship of tank crew performance (maintenance proficiency and tactical performance) to the supervisory actions of the tank commander was examined. With regard to maintenance, crewmen needed a substantial amount of supervision. In the high performing crews this direction was provided by either the crewmen themselves or by the tank commander. In the low performing crews supervision was given by both the tank commander and the crewmen, reflecting role confusion, ineffective communication, and lack of confidence between the tank commander and crewmen. Tank commanders often performed about as many inspective and corrective actions as did the individual crewmen, suggesting that commanders may be confused as to whether their primary role is manager or operator. In all crews there was a tendency for crewmen to give status reports to other crewmen rather than to the tank commander, thereby depriving the commander of relevant information. No consistent findings occurred with the tactical performance test due to measurement problems.

Shaw, M.E., & Blum, J. M. Effects on leadership style upon group performance as a function of task structure. Journal of Personality and Social Psychology, 1966, 3, 238-242. (DTIC No. AD 605 854)

Fiedler's hypothesis that directive leadership is more effective when the group task is either highly structured or unstructured was examined. Leadership behavior was manipulated by instructions. Task structure was manipulated by using problems that varied in number of possible solutions. The tasks were equivalent on the following dimensions (based on previous scaling studies); intellectual - manipulative requirements, cooperation requirements, difficulty, population familiarity, and intrinsic interest.

Directive leadership behavior was more effective than nondirective leadership for only the highly structured task (i.e., one solution). The authors inferred that with multiple solution tasks the requirements for nondirective leadership are great -- motivating, advising, rewarding, giving support.

Terborg, J.R., Castore, C.H., & DeNinno, J.A. <u>A longitudinal field investigation of the impact of group performance and cohesion</u> (Office of Naval Research Organizational Effectiveness Research Programs, Contract No. N00014-67-A-226). Lafayette, Ind.: Purdue University, May 1975. (DTIC No. AD A003 909)

The performance and cohesiveness of university land surveying teams (3-4 individuals) over a three-month university course was examined. Teams were placed into one of four categories: high ability and high attitude similarity, high ability and low attitude similarity, low ability and high attitude similarity, and low ability and low attitude similarity. It was expected that the high ability and low attitude similarity dimensions would result in higher performance and higher levels of cohesiveness than low ability and low attitude similarity.

Performance and cohesion measures were taken at six times during the course. High ability groups exhibited the best performance, while attitudinally similar groups expressed the greatest cohesiveness. Performance increased over time, while there were no significant changes in cohesiveness with time. Attitude similarity and cohesion scores were not significantly correlated until the fourth project. The cohesion-performance relationship was initially positive, but was negative by the last project (perhaps due to the fact that the high ability groups knew they were already assured of a high grade). Post hoc analyses showed that the low ability/low similarity condition resulted in the highest frequency of missing data, an indication of greater withdrawal behavior by these groups according to the authors.

Trow, D.B. <u>Teamwork under turnover and succession</u> (Technical Report No. 2, Office of Naval Research contract Nonr 3679 (00), project NR 170-331). Endicott, N.Y.: Harpur College, June 1964. (DTIC No. AD 601 816)

See reference in Section C1. One variable examined was the level of intelligence of team member replacements. Team performance declined when the replacement's level of intelligence was lower than that of his predecessor's.

Tuckman, B.W. Group composition and group performance on structured and unstructured tasks. <u>Journal of Experimental and Social Psychology</u>, 1967, <u>3</u>, 25-40.

See reference in Section C1. Groups composed of members with ability to handle unstructured tasks performed better on an abstract task than groups with members low in such an ability. There were no performance differences between the two ability groups on structured tasks.

Zander, A.F. Group aspiration and the desire for group achievement (Final Report, AFOSR 70-C528TR). Ann Arbor, Mich.: University of Michigan, March 1970. (DTIC No. AD 706 423)

Zander summarized five years of laboratory work and some field work on group aspirations. Some of the major findings were as follows:

1. Group members select and change their group level of aspiration on grounds similar to those employed by solo individuals (p. 2).

2. Group levels of aspiration are highly susceptible to outside social pressures (p. 3).

3. Members develop group-oriented motives, designated as a desire for achievement of group success and a desire to avoid the consequences of group failure (p. 3). The desire for group success is more likely to be aroused in a strong group than a weak one, in a successful group than in a failing one, in a member with a central position within the group than in one with a peripheral-position, and in a group where this desire is perceived to be the norm where this norm is not present.

4. Individuals who differ in their personal motives to achieve success or to avoid failure prefer quite different group aspirations (p. 4). The former prefer intermediate difficulty tasks; the latter do not.

5. Person-oriented and group-oriented achievement motives are independent dispositions with independent sources and effects; thus, they can either supplement or contradict the effect of each other (p. 4).

6. Members' evaluations of their group's performance indicate that they take the level of group aspiration seriously (p. 5). However, they do not uniformly believe that group performance indicates their own level of personal competence, yet under some conditions their self-regard is deeply affected by the quality of the group's performance.

7. A group's output increases as the member's desire for group success increases, as long as the task is not extremely difficult (p. 5).

Ziller, R.C., Behringer, R.D., & Hawkins, C.E. Esprit, group dynamics, and motivation (Research Memorandum 63-6). Newark, Del.: University of Delware, Center for Research on Social Behavior, April 1963. (DTIC No. AD A070 225).

The volume reported a series of studies that focused on problems concerning the assimulation of newcomers to groups and depersonalization in large organizations. Theoretical analyses of the problems were presented, followed by both field (i.e., military) and laboratory investigations.

In summary, laboratory study results showed that a newcomer's talents were used to greater advantage under conditions of intergroup competition, and that groups that anticipated changes in group membership accepted a formal group structure and a new leader more readily than groups that did not anticipate such changes (p. 2). Field studies with rifle squads and artillery sections indicated that the leader's ability to differentiate among the members of his unit (i.e., "know your men") was associated with higher team morale and military effectiveness and that higher rated leaders tended to possess a more positive attitude toward the trainability of all personnel in their units (p. 3).

D. DESCRIPTIVE STUDIES OF THE CHARACTERISTICS OF EFFECTIVE/INEFFECTIVE TEAMS AND TEAM MEMBERS

The studies in this section concentrated primarily on simply describing the characteristics of effective and ineffective teams. Except for the McRae study, all involved military teams.

1. Leader Personality Traits

   Blades & Fiedler (1976)
   Clark (1969b)
   Greer (1955)
   Lange (1967)

2. Leader Skill/Ability

   Blades & Fiedler (1976)
   Crawford (1947)

3. Member Personality Traits

   Greer (1955)
   Greer, Galanter & Nordlie (1954)
   Goodacre (1953)
   McGrath (1961)
   Mumford (1976)
   Shirom (1976)

4. Member Skill/Ability

   Torrance (1953)

5. Communication within Teams

   McRae (1966)
   Sanders et al. (1975)
   Siskel et al. (1965)

6. Combat Studies

   McKay et al. (1965)

7. Other

   Dyer et al. (1980)

Blades, J.W., & Fiedler, F.E. The influence of intelligence, task ability, and motivation on group performance (Technical Report 76-78). Seattle, Wash.: University of Washington, Department of Psychology, January 1976. (DTIC No. AD A021 283).

Two studies investigated the relationship of leader and subordinate intelligence, skill, and motivation with organizational performance as a function of leader directive or participative style. The sample consisted of company-sized Army mess halls (ranging from 2 to 6 people).

As predicted, it was found that when the leader was participative and nondirective and members were highly motivated, member intelligence correlated positively with performance. Member task ability correlated

positively with performance under non-directive management and high member motivation. Leader intelligence and task ability correlated positively with group performance when the leader was directive in his approach and his group members were motivated to complete the task.

The authors concluded that moderator variables must be examined in group performance studies. In other words, "why should a style (participative management) which may utilize dull and incompetent group members serve to increase the performance of the organization? Likewise, how can we expect group members to contribute significantly to group decision making or to the execution of the group task unless they are motivated to do so? And finally, and perhaps somewhat less obviously, how can a leader's intelligence and task ability affect group performance unless the leader is willing do be directive and the group members are willing to accept his decisions and carry them out?" (p. 13, 14).

Some conditions were found where leader and member intelligence scores, as well as motivation scores, correlated negatively with group performance. The authors concluded that further research was needed in these areas.

Clark, R.A. Developing a functional theory of leadership. In Collected papers prepared under work unit INTERSQUAD: A study of the factors which account for differences between effective and ineffective rifle squads. (HumRRO Professional paper 3-69). Washington, D.C.: George Washington University, Human Resources Research Office, March 1969, pp 25-31. (b) (DTIC No. AD 686 621)

See reference in Section C2. Clark focused on leadership roles and functions associated with the rifle squad's combat effectiveness.

Crawford, M.P. (Ed.) Psychological research on operational training in the Continental Air Forces (Army Air Forces Aviation Psychology Program, Research Report No. 16). Washington, D.C.: Army Air Forces, 1947. (DTIC No. AD 651 792)

Chapter 12 of this volume focused on the selection and evaluation of lead aircrews. A general description of the roles played by each member of the crew indicated that a high degree of crew coordination is required for successful crew performance. In selecting lead crews for the Lead Crew School at Muroc, California, instructors were reported to require a high degree of individual skill first and a high quality of teamwork second. The relationships between pilot and flight engineer, between pilot and navigator, and among the navigator, bombardier, and radar observer were particularly important. In some cases the presence of an average crew member would be overlooked if the teamwork exhibited by the crew was very good.

Despite the stress upon teamwork, operational definitions of teamwork and measures of teamwork were difficult to obtain. Research

reported in the chapter focused primarily upon crew ratings as estimates of teamwork. Data were presented on the relationship of different variables to crew proficiency (measures of bomber accuracy). Such predictor variables included ratings on crew proficiency, measures of individual skill, and training scores. One question raised by the study was whether the lead crew does in fact have characteristics above and beyond its members or whether it is merely the sum of its members. The final conclusion was that an answer to this question would have to wait the development of more adequate criteria of crew and individual proficiency.

Dyer, J.L., Tremble, T.R., & Finley, D.L. The structural, training and operational characteristics of Army teams (ARI Technical Report 507). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, Ft. Benning Field Unit, June 1980.

In the first part of the study TRADOC experts identified Army teams (defined as groups of 2 to 11 men who normally perform their activities in an interactive manner) within 12 branches of the Army. The structural characteristics (size, member rank, leader rank, skill level of members, etc.) of these teams were then obtained. Teams that perform non-routine tasks (emergent as opposed to established tasks) were also identified. A total of 255 distinct teams were identified. Infantry, Field Artillery and Armor branches contained the greatest number of teams. Teams likely to perform non-routine tasks were concentrated in Infantry, Armor, and Engineer branches.

The second part of the study surveyed active Army units in order to obtain data on the operational characteristics, training programs, and operational problems of the teams identified in the first part of the study. The primary training problems and constraints identified were turn-over of team personnel, understrength teams, unqualified personnel, insufficient time to train, and unrealistic training. Of the team characteristics surveyed (e.g., member coordination, task interdependence, dependence upon equipment), only one was rated as atypical of Army teams -- compensation by one member for inadequate performance by another member.

The results provide a data base for future team research within the Army. An appendix listed all teams identified in the study.

Greer, F.L. Small group effectiveness (Series 1955, Institute Report No. 6, Prepared for Office of Naval Research). Philadelphia, Pa.: Institute for Research in Human Relations, 1955. (ASTIA No. AD 82 042)

The study focused on individual and intragroup personality correlates of small group effectiveness. The effectiveness of nine-man Infantry rifle squads ($n=100$) performing four simulated combat tasks was examined (squad as point of an advance guard, squad in independent attack, interior squad of a platoon on defense, and squad on a

reconnaissance patrol). Various personality and sociometric measures were given to the squads.

Personality and sociometric measures correlated moderately (maximum r = .40) with performance measures. Personality - effectiveness correlations increased as a function of the amount of time the men had been together in the same squad. The author cautioned that sociometric rejection responses may not be useful in determining group cohesiveness since such responses may be given for various reasons ranging from dislike to lack of familiarity with another individual.

Greer, F.L., Galanter, E.H., & Nordlie, P.G. Interpersonal knowledge and individual and group effectiveness. Journal of Abnormal and Social Psychology, 1954, 49, 411-414.

The major hypothesis of the study was that knowledge of interpersonal relationships by individuals within a group is related to effective group behavior; specifically, that groups composed of individuals with more accurate social perceptions about their groups than groups with less perceptually accurate individuals will be more productive and effective. The groups examined were Infantry squads and group performance was based on four squad missions. Measures of social perceptions were based on each individual's ranking of the extent to which he liked each group member as compared to his perceptions of the extent to which each member was liked by the group as a whole.

More effective squads on the missions were more likely to have squad leaders and members with more accurate perceptions of the squad members' preferences. No differences were found between effective and ineffective squads in terms of the length of time they had worked together nor the average intelligence of the squad. However, the squad leaders of the more effective squads had higher intelligence scores.

Goodacre, D.M. Group characteristics of good and poor performance combat units. Sociometry, 1953, 16, 168-178.

Performance of nine-man rifle squads during a six-hour combat exercise was determined. Squads were divided into the 13 highest and 13 lowest ranking squads, based on umpire ratings. Members of these squads were interviewed regarding such variables as: squad member stability, the value attached to the group by persons outside the group, the value attached to the group by the group members, degree of individual and sub-group harmony, extent of overt acts of friendliness and closeness among group members, and the hierarchical structure of the group as perceived by group members.

In general, the sociometric questions did not distinguish between effective and ineffective squads. Those variables that did distinguish between the two groups indicated that the members in the effective squads agreed with the squad leader regarding the conduct of the problem, that there was more assumed undelegated authority within such squads, that squad members would retain essentially the same squads if

they had an opportunity to create their own squads, that they were proud of their squad, and that they thought members from other rifle squads would like to be in their squad.

Lange, C.J. Leadership in small military units: Some research findings (HumRRO Professional Paper 24-67). Washington, D.C.: George Washington University, Human Resources Research Office, June 1967. (DTIC No. AD 658 245)

The paper summarized research on Infantry platoon leaders. Interviews were held with platoon leaders as well as with members of each leader's platoon regarding behavior of the leader in nine different situations. A content analysis of these interviews was conducted. Five important functions of a leader were identified; functions that affect the performance and morale of the group members. Giving information to squad or platoon members that will improve their performance is important. Leaders should encourage high standards of performance when assigning work. Rewards and punishments should be used appropriately when recognizing achievement. Effective leaders minimize the disrupting effect upon the entire group of such individual factors as personal or physical problems. Effective leaders encourage participation of group members by asking for advice and suggestions, but retain their decision-making power. The remainder of the paper presented a conceptual framework developed from the research findings and a general approach to be followed in the development of an experimental leadership training program.

McGrath, J.E. Assembly of quasi-therapeutic rifle teams (Technical Report No. 13). Urbana, Ill.: University of Ilinois, Department of Psychology, Group Effectiveness Research Laboratory, July 1961. (DTIC No. AD 680 204)

The extent to which an individual perceived a teammate as warm, supportive, and accepting, and whether such perceptions were based on the general way people view each other (refered to as perceptual) or whether they were based on the way people act towards one another (referred to as behavioral) were investigated within the context of three-man tournament rifle marksmanship teams. Results indicated that perceptual tendencies, rather than the behavior of teammates, tended to determine the initial interpersonal relations in the group. Teams composed of individuals who perceived their teammates as warm and supporting tended to focus on interpersonal relationships rather than on task activity. On the other hand, teams composed of teammates who did not necessarily view their colleagues as warm and supporting focused their energies on the task.

The authors suggested that two types of individuals existed (p. 25-26). For some individuals success is defined primarily in terms of their effectiveness on the task; task success then leads to adjustment and favorable reactions to teammates. For others, personal success in new team situations seems to be defined in terms of social relations with teammates. In the initial stages of group development such

"teammate-oriented" persons do not seem to have sufficient task motivation for effective task performance. Yet these individuals favorably evaluate teammates who do well on the task. Thus it is possible that in the long run these persons will become more motivated to succeed on the task in order to gain the rewards of incresed esteem from teammates.

McKay, J.G., Cianci, S., Hall, C.E., & Taylor, J.E. <u>Some factors which have contributed to both successful and unsuccessful American Infantry small-unit actions</u> (HumRRO Research Memorandum No. 12). Ft. Benning, Ga.: U.S. Army Infantry Human Research Unit, April 1959. (DTIC No. AD 260 994)

The combat literature of World War II and the Korean War was reviewed to identify factors that affected the success of Infantry small-unit actions (e.g., rifle platoon). Many of these factors have implications for Infantry squad training.

Inferences drawn from this body of literature were as follows. The unit needs to use supporting fires (artillery, mortar) properly during group operations. Proper functioning of command net communications and person-to-person communications contributes to small-unit success. Soldiers must be both mentally and physically prepared for battlefield conditions (replacements should not be rushed into battle; they need to know their leaders, the battlefield situation, the consequences of carelessness). Poor information dissemination, particularly among adjacent units, frequently contributes to unsuccessful actions. Higher echelons need to give lower units time to plan and to orient the unit. All men need to be briefed in order to ensure a better success. As one platoon sergeant stated, "Every man in the squad should listen to his squad leader's orders with the thought in mind that he may have to be the squad leader before the battle is over" (p. 4). Reporting should be accurate and timely. Units need to maintain security and look for opportunities for surprise. Units must anticipate and plan for combat losses of key personnel in order to engage in effective sustained action. Weapons and personnel need to be carefully selected for specific missions. Troops need to make tactical use of the terrain.

McRae, A.V. <u>Interaction content and team effectiveness</u> (HumRRO Technical Report 66-10). Alexandria, Va.: Human Resources Research Office, George Washington University (HumRRO Division No. 4), June 1966. (DTIC No. AD 637 311)

Four-man groups were created to solve a group maze problem that could only be solved by verbal interaction among team members. Errors and time to solve problems were the measures of team effectiveness. Verbal interactions among team members were coded as follows:

Organizational Interactions

1. Procedural innovation
2. Reinforcement or maintenance of procedure

3. Repudiation or rejection of procedural innovation
4. Interaction that is motivational or exhortative

Task-Specific Interactions
1. Specifying action for oneself
2. Specifying action for another or others
3. Request for information
4. Giving information

Residual Interactions
1. Emotional expression not contributory to task solution
2. Nonrelevant interaction
3. Interaction with experimenter

Total task specific interactions correlated positively with time to solve problems. When time was partialed out, total task-specific interactions correlated negatively with errors. In general, organizational interactions did not correlate strongly with team effectiveness measures. However, the volume of such interactions was much smaller than task-specific interactions.

Mumford, S.J. Human resource management and operational readiness as measured by refresher training on Navy ships (NPRDC TR 76-32). San Diego, Calif.: Navy Personnel Research and Development Center, February 1976. (DTIC No. AD A022 372).

Scores earned by ships during refresher training (i.e., simulated combat) were related to measures of organizational effectiveness (called "human resources"). The predictor variables reflected five major dimensions: command climate, supervisory leadership, peer leadership, work group processes, and outcome measures. The strongest correlation occurred between work group and team effort indices (subscores within the peer leadership and work group process dimensions) and the refresher training scores. The authors stated that "it seems logical to expect that those teams who, to a great extent, perceive the work group as maintaining high standards of performance, encouraging group members to give their best effort and work as a team, stressing a team goal and being able to effectively deal with emergency situations and mission requirements would be able to handle (refresher training) exceptionally well" (p. 12). Areas that did not correlate highly with the refresher scores were motivation, human resource emphasis, and satisfaction. The authors recommended expanding the study to include the Atlantic fleet in order to cross-validate the findings obtained with the Pacific Fleet.

Sanders, M.G., Hofmann, M.A., Harden, D.F., & Frezell, T.L. Communication during terrain flight (USAARL Report 75-13). Fort Rucker, Ala.: Army Aeromedical Research Laboratory, March 1975. (NTIS No. AD A009 336)

The report focused on the importance of standard communication procedures between helicopter pilots and co-pilots in nap-of-the-earth (NOE) and low level contour flights, and upon developing standardized

terminology that could be used in future instructional settings. Although standard terms have been developed to describe the terrain, no emphasis has been placed on standardization of terms which the navigator uses to guide the pilot over the terrain. Observations indicate that "too often the navigator gives a direction which either requires the pilot to focus inside on the instrument panel for reference or produces some uncertainty in the pilot as to the exact meaning of the instructions. Either case can cause a slower reaction time by the pilot and could result in a degradation in his efficiency in handling the helicopter" (p.1).

Helicopter crews that had trained together were compared to helicopter crews composed of new partners during NOE training. The latter groups spent more time in communicating, indicating perhaps a need for more conversation regarding navigation with new flight partners; a problem that might be lessened if standardized navigation terms were taught. Terms that either were confusing or required the pilot to refer to his instruments were used frequently. Slang jargon used by the copilot was frequently not understood by the pilot. The findings indicated that the pilot would be more likely to understand the copilot if the vocabulary were limited to a finite number of navigation directions, thereby allowing the crew to concentrate on the more intricate elements of navigation and mission accomplishment.

Shirom, A. On some correlates of combat performance. Administrative Science Quarterly, 1976, 21, 419-432.

Enlisted personnel up to the rank of platoon commander from several Infantry rifle platoons of the Israel Defense Forces were requested to give ratings on the combat performance of peers within their units. Possible predictors of individual combat performances were: (a) the individual's perception of his combat preparedness and his unit's preparedness based upon a standardized interview; (b) responses to questionnaire items regarding the unit's morale and team spirit and the commissioned officer's combat proficiency; (c) peer ratings of social support provided and received; and (d) the individual's normative commitment to the objectives of war based upon a standardized interview. It was hypothesized that combat preparedness, normative commitment, attitudes toward officers and unit, and social support would each be positively associated with combat performance in declining order of magnitude.

The expected pattern of correlations did not occur, however. The highest correlate of individual combat performance was the social support provided to unit members by that individual as indicated by peer ratings ($r = .56$). All other correlations were between $-.27$ and $.22$. The author concluded that measures of interpersonal relationships might be the most powerful predictors of individual soldier's combat performance in future studies.

Siskel, M., Lane, F.D., Powe, W.E., & Flexman, R.E. Intra-crew communication of B-52 and KC-135 student and combat crews during selected mission segments (AMRL-TR65-18). Wright-Patterson Air Force Base, Ohio: Air Force Systems Command, Aerospace Medical Research Laboratory, May 1965. (DTIC No. AD 617 598)

Work with integrated aircrew simulators had shown an inverse relationship between the rate of communication within a crew and crew proficiency measures during training. On the basis of these findings, the authors predicted that the same relationship would exist during actual flight missions. Two types of aircraft were examined, B-52 and KC-135. For each aircraft student and combat crews were compared. Tape recordings were made of crew communication on each mission. An attempt was made to control the types of missions flown by students and combat crews, but perfect control was not possible. For the B-52, bomber take-off and bomb runs were analyzed. For the KC-135, take-off for tanker missions, and airfueling were analyzed.

The expected results occurred in only two of the four missions: bomber takeoffs and tanker air refuelings. The authors interpreted the results as being consistent with the original hypothesis by considering the lack of control over some missions and the differences in difficulty between some of the student and combat crew missions. Results showed that communication patterns differed with mission, and in some cases, varied with crew experience. During take-offs, most of the communications occurred between the two pilots. During bomber runs, communications were between the two navigators. During air refueling, student pilots tended to request information from the boom operator, while combat pilots tended to rely on the boom operator to volunteer information.

Torrance, E.P. Crew performance in a test situation as a predictor of field and combat performance (HFORL Report No. 33). Washington, D.C.: Bolling Air Force Base, Human Factors Operations Research Laboratories, Air Research and Development Command, March 1953. (a) (DTIC No. AD 014 473).

A basic assumption of the study was that human behavior and the behavior of human groups are psychologically self-consistent, and that testing procedures which elicit a wide range of individual and group behaviors will to some extent predict future group behavior under different conditions. A battery of group performance tests were developed in order to analyze the difficulties combat air crews experience in working together. These tests were administered during Strategic Air Command (SAC) Advanced Survival School. The battery consisted of "lab-like" situations, rather than situations the crews might encounter in combat (a problem-solving test, group-interaction picture-story test, a group-squares test). Behavior of the crews during the tests and crew output were measured. Ratings were made on such dimensions as organization, utilization of manpower, degree of member participation, leadership, coordination, supervision, and flexibility.

Two criterion measures were used. One was school instructor ratings of the crews on such dimensions as route selection, navigation, comunications, functioning as a unit, and care and use of equipment. The other criterion was related to combat performance of the crews and was measured at a later date. The crews that had been in combat were designated as good or poor based on ratings of superior officers and on percentage of successful missions. The remaining crews were labeled "drop-out" crews since they had been designated during school as not being combat-ready and had not been in combat.

Differences on the test battery were found between the effective and ineffective crews based on instructor ratings as well as among the good and poor combat crews and the drop-out crews. For example, good crews were characterized by superior organization and use of manpower, degree of participation, leadership, coordination, supervision, flexibility, and success in problem-solving. Such crews also expected task-oriented groups to find satisfactory outcomes, to function in an orderly manner, and to be productive, whereas such expectations occurred less frequently in poor crews.

E. TEAM TRAINING STUDIES

1. Military Tasks and Approximations to Military Tasks

Articles describing research or conceptual efforts in the area of military team training are presented here. These efforts differ from the experimental studies cited in Section C in that they are broader in scope and focus specifically on military problems.

1. Leader Training

Baker et al. (1964)
Jacobs (1968)
Jacobs, Rahn & Moore (1965)
Root et al. (1979)
Shriver et al. (1979)

2. Tactical Training for Teams

Biel et al. (1957)
Chapman et al. (1959)
Dees (1969)
George (1967a, 1967b)
George (1979)
Havron et al. (1955)
Havron & McGrath (1961)
O'Brien et al. (1978)
Root et al. (1979)
ARI studies on REALTRAIN (1976-1979)
USARIEM Studies on Field Artillery FDC (1978-1980)

3. Individual-Team Training Sequence

Dyer (1980)
Finley et al. (1972)
O'Brien et al. (1978)
Schrenk, Daniels & Alden (1969)
Ohio State Un. CIC Studies (1965-1966)

4. Training Devices

Finley et al. (1972)
Prophet & Caro (1974)
Schrenk, Daniels & Alden (1969)
Thurmond & Kribs (1978)

5. Training Fidelity

Ohio State Un. CIC Studies (1965-1966)

6. Communication Training

Siegel & Federman (1973)

7. Team Training to Enhance Individual Performance

BESRL Studies on Image Interpretation (1965-1971)

8. Transfer of Training

Briggs & Johnston (1966)

9. Team Feedback

Alexander, Kepner & Tregoe (1962)   Findlay, Matyas, & Rogge (1955)

Alexander, L.T., Kepner, C.H., & Tregoe, B.B. The effectiveness of knowledge of results in a military system-training program. Journal of Applied Psychology, 1962, 46, 202-211.

The effect of knowledge of results on the performance of four 13-man Air Force Air Defense crews was examined. Knowledge of results was operationally defined as feedback provided during debriefing sessions after each training session. The feedback was organized by Air Defense functions (e.g., surveillance, tactical action, lateral telling), and opportunity was provided for crew discussion.

A pretest posttest design was employed, with two crews assigned to the experimental feedback condition and two crews assigned to the control condition (practice only). The pretest and posttest each consisted of two exercises, while the training consisted of twelve exercises. A particularly stressful problem was also presented at the completion of training to evaluate the hypothesis that system training with knowledge of results would increase the flexibility and adaptability of crews.

The experimental crews improved substantially from pre- to posttest on 15 of the 17 criterion measures, while the control crews generally remained at approximately their initial levels or decreased slightly. Experimental crews performed better than the control crews on the stressful transfer exercise as well.

Although the experimental crews improved on almost every criterion measure, the degree of improvement varied with the function measured. In a discussion of the results, the authors distinguished two forms of feedback: feedback provided in the debriefing session, and feedback obtained during actual performance of the functions. The authors related this latter form of feedback to the "visibility" of the function (i.e., the availability, in the operating environment, of information about the adequacy of the performance of the function). It was expected that there would be an inverse relationship between the function's visibility and the degree of improvement on the function for those crews provided with debriefings since the only way crews could obtain feedback on the less visible functions was through the debriefings. Post hoc analyses indicated that this was the case. The authors discussed briefly ways of measuring the visibility of a function.

Note. - Although the authors stressed the negative relationship between visibility and performance gain for the experimental crews, a positive relationship was found between visibility and performance improvement for the control crews. It would seem that both relationships can be explained in terms of the type of feedback which was dominant during training. In the experimental groups, the

debriefing sessions were stressed; in the control group, the only form of feedback was that obtained during operation of the mission itself.

The results support the importance of carefully structured debriefing sessions for military teams. Extensive logs of each exercise were maintained in order to provide adequate feedback.

Baker, R.A., Cook, J.C., Warnick, W.L., & Robinson, J.P. Development and evaluation of systems for the conduct of tactical training at the tank platoon level (HumRRO Technical Report 88). Alexandria, Va.: Human Resources Research Office, April 1964.

The main focus of the study was the development and testing of a series of tactical training exercises for the tank platoon leader. However, one phase of the study also examined the effectiveness of such exercises for tank crews. Tank crews were exposed to the Miniature Armor Battlefield (MAB), a terrain board on which tank platoon maneuvers were simulated using radio controlled tank models. Tank crews were given a week of MAB training that consisted of ten tactical exercises. On the first four MAB exercises each crew member served once in each crew position. For the last six problems, each crewman had a permanent position, except that tank commanders rotated as platoon leaders in the exercises. Critiques were held following each exercise.

Training effectiveness was measured by an objectively scored field test of the proficiency of tank platoon personnel to conduct a platoon mission against a live aggressor force under simulated combat conditions. Crews trained on the MAB scored higher on the field test than crews not so trained. Performance was higher in the following areas: responsiveness to commands and coordination with the platoon leader, application of tactical principles, use of terrain, combat gunnery, and combat leadership in emergency situations. Ratings of the crews by experienced armor officers and NCOs were also higher for the MAB trained tank crews.

Biel, W.C., Chapman, R.L., Kennedy, J.L., & Newell, A. The systems research laboratory's air defense experiments (P-1202). Santa Monica, Calif.: Rand Corporation, October 23, 1957. (DTIC No. AD 606 272)

Chapman, R.L., Kennedy, J.L., Newell, A., & Biel, W.C. The systems research laboratory's air defense experiments. Management Science, 1959, 5, 250-269.

These two papers describe some of the methodological problems encountered in the Rand's Systems Research Laboratory Air Defense experiments and some of the basic principles learned about the behavior of organizations. In the researchers' attempts to manipulate task difficulty, they soon discovered that task difficulty was not strictly a function of the number of aircraft in the area, but of the difference between the number of aircraft and the crew's immediate capacity to handle the traffic load. Thus for training purposes, they had to

estimate how fast the crew would learn in order to increase task difficulty fast enough to continue to challenge the crew, but not so fast that the task would be too difficult. With experience, the crews performed more effectively --- they learned procedural shortcuts, reassigned functions to crew members, learned to distinguish relevant from irrelevant information, and increased motor skill performance. Although debriefings on performance were regularly given, it was difficult to determine their effect upon later crew performance. Two types of stress were identified: failure stress (disparity between aspirations and performance) and discomfort stress (difference between effort demanded by tasks and that which could be handled comfortably).

Performance of a crew depended upon what is was trying to do and the situation it faced. Researchers questioned whether there was a right or correct organizational structure, a right decision process, and a right expected payoff. The major problem seemed instead to be one of designing and managing for operational flexibility. The researchers concluded that three factors were necessary to enhance organization (group) learning: clarify the goal, give the total organization experience with tasks of increasing difficulty, and provide immediate knowledge of results.

Briggs, G.E., & Johnston, W.A. Influence of a change in system criteria on team performance. Journal of Applied Psychology, 1966, 50, 457-472. (a)

A simulated ground-controller aerial intercept task was used to investigate the effect of training under simple criterion conditions (i.e., a single criterion of either time or coordination) as compared to complex criterion conditions (i.e., two incompatible criteria were stressed, time and coordination) with two-man teams. When the simple transfer criterion was used the teams readily adapted to the criterion that was stressed during transfer, irrespective of the criterion that had been stressed during training. However, when the complex transfer criterion was stressed, the teams continued to emphasize the single aspect of performance upon which they had been trained. However, the results also indicated that teams may have been attempting to achieve some compromise between both criteria, since differences on each criterion among the complex criterion transfer groups were smaller than the corresponding differences among the simple-criterion transfer groups.

Dees, J.W. Squad performance as a function of the distribution of a squad radio (HumRRO TR 69-24). Alexandria, Va.: Human Resources Research Organization, December 1969. (DTIC No. AD 701 152)

The procedures used to evaluate Infantry rifle squad performance have implications for future team research. The three scenarios used were described in detail. Two criterion measures of team success were used: time to complete tasks and ratings of squad proficiency. Given the limited number of squads in the study, time to complete tasks was

the more sensitive measure, in that only it provided statistical discrimination among the eight radio conditions examined.

Two of the study's major conclusions impact on the teamwork within a rifle squad. The ability of the squad leader to communicate with squad members was most critical under enemy fire and limited visibility conditions. The squad leader became overloaded when fire team leaders and other squad members constantly transmitted information to him.

Dyer, J.L. The initial training of individual and team skills: An exploratory investigation of Engineer bridge specialists (ARI Working Paper, FBNG FU 80-1). Fort Benning, Ga.: U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Benning Field Unit, October 1980.

The sequence of training individual and team skills within an Engineer bridge platoon as the platoon was taught how to construct and use the assault ribbon raft/bridge was observed. Individual skills were defined as those activities that could be or were performed independently of other team members; team skills referred to activities that had to be performed in response to the actions of other team members or that directed the actions of other team members. In general, individual skills were trained before team skills, and most of the formal instruction focused on the acquisition of individual skills. Team skills were acquired mainly through observation and imitation of the instructors. Although some cross-training of bridge positions occurred, it was not possible to determine the effect of this cross-training.

Time analyses of the construction process indicated that the training procedures were effective, in that the National Guard Unit almost met the Army time standard for constructing a five-day raft. Observations also indicated that team skills such as coordination between the boat drivers and raft commanders, and sequencing/timing of boat and bay launches are critical in that if they are not mastered, it becomes very difficult to meet the Army time standards.

Findley, D.C., Matyas, S.M., & Rogge. H. Training achievement in basic combat squads with controlled aptitude (HumRRO Technical Report 16). Washington, D.C.: George Washington University, Human Resources Research Office, January 1955. (DTIC No. AD 073 777)

The distribution of aptitude within Infantry squads was varied in an effort to determine the effect of such variations upon the performance of low-aptitude men. Three squad variations were examined: squads with low aptitude men only; squads with 25% low, 50% medium and 25% high aptitude men; and squads with 50% low and 50% high aptitude men. Low aptitude men scored at or below 90 on the Army Classification Battery; medium men scored between 91 and 110, and high aptitude men scored 111 or higher. The expectation was that the mixed ability squads would perform best since the high ability individuals would assist the low ability individuals. Such assistance was anticipated because of the

special competition-reward in which all squads participated (see paragraph 3 below for a description of the program). Each platoon within the experimental companies consisted of four squads with the same aptitude distribution.

The study was conducted over an eight-week period with weekly proficiency/performance tests. At the conclusion of the study a performance test on basic combat and a paper-pencil test entitled the Basic Military Proficiency Test were given. None of the weekly tests nor the final tests showed significant differences among the low-aptitude men within the three types of squads.

Throughout the study each squad was placed in competition with the othersquads within its platoon. Within each platoon a winning and a losing squad were designated at the end of each week. Winning squads were given three rewards: week-end passes, exemption from work details, and priority in mess line. The losing squads usually received no passes, ate last, and performed most of the extra-duty work details the following week. Men in the other two squads were uncertain whether they would receive any of the rewards. A comparison was then made with other companies in the same stage of training but who had not participated in the special competition-reward program. The Basic Combat Test and the Basic Military Proficiency Test were given to men in these companies, as well as a map reading test and a squad tactics test (the later tests were administered at the end of weekly training). Comparison of individuals within the experimental and nonexperimental groups by ability level (low, medium and high) showed that the experimental groups performed higher than the non-experimental groups at each ability level.

The authors concluded that the ability mix of the squad did not facilitate learning of low aptitude men, but that competition, weekly squad rewards, and weekly testing facilitated learning of all squad members.

Findley, D.L., Rheinlander, T.W., Thompson, E.A., & Sullivan, D.J. Training effectiveness evaluation of Naval training devices Part I: A study of the effectiveness of a carrier air traffic control center training device (Technical Report, NAVTRAEQUIPCEN 70-C-0258-1). Westlake Village, Calif.: Bunker Ramo, Electronic Systems Division, August 1972. (DTIC No. AD 751 556)

The training effectiveness of a Naval Carrier Air Traffic Control Center (CATCC) training device was evaluated. This device is primarily a team training device, but can also be used for individual training.

Existing ship personnel were trained as teams on the CATCC and then returned to their ship as a team to perform actual aircraft recoveries. Team performance during training as well as during shipboard recoveries was evaluated. Separate indices of team, subteam, and individual performance on such objective tasks as minimum recovery time and minimum accident rate were constructed. More subjective measures such as performance ratings were also obtained. Since the difficulty of a

recovery problem varied with the positions held by team members, separate indices of difficulty for team, subteam, and individual functions had to be constructed for each problem.

Since the authors were not allowed to control the training procedures, the design of the study was limited by the small number of teams, the lack of control over training problem sequence and difficulty, the amount of training, and team membership. Obviously, the difficulty of actual shipboard recoveries could not be controlled either.

The four major findings and conclusions that related to team performance were as follows. First, team performance was affected primarily by the difficulty of the recovery problem, repeated use of the training device (performance improved with training), and by the effectiveness of the instructors. Second, the training device allowed variations in problem difficulty. Such variations however did not affect all personnel of subteams equally, but only selected personnel, depending upon the particular problem examined. Thus in some team situations, a general index of task difficulty may be difficult to construct or be inappropriate. Third, communications efficiency (transmittal of maximum information in minimal time) of the team varied with experience of the team and with the difficulty of the recovery. Fourth, training all team members as a team prior to on-the-job performance enhanced recovery operations. Neither individual nor team training was optimized when much cross-training was done and individuals received little training in their own positions.

George, C.E. Training for coordination within rifle squads. In T.O. Jacobs, J.S. Ward, T.R. Powers, C.E. George, & H.H. McFann (Eds.) Individual and small-unit training for combat operations (HumRRO Professional Paper 21-67). Alexandria, Va.: Human Resources Research Office, George Washington University, May 1967. (a) (DTIC No. Ad 653 845)

The paper by George focused on four studies that examined training rifle squads to coordinate member behavior. Initial studies indicated that individuals low on team motivation (motivation for coordination) would unnecessarily fire on the targets of other men. Such behavior was also undesirable in that it wasted ammunition. Instruction in how and when to coordinate member actions reduced this type of behavior.

In another study groups trained under conditions that required intrateam coordination and communication performed better on live fire problems than did groups without such training. With repeated trials and between trial critiques, the control groups did achieve the level of the experimental groups. Peer ratings of acceptability of members of the same squad in combat initially showed higher status ratings for the experimental group members than control group members with this difference decreasing over time.

In the next study, emergency events such as simulated casualties and weapon failures were used to create requirements for coordination. Observers rated squads on such dimensions as volume of fire, degree of coordination in reaction to emergencies, and individual performance. Critiques between trials were also provided. Distribution of fire scores improved over the trials as did the rated amount of coordination among squad members (e.g., alternating attention between cues from the objective area and conditions within the team, passing the word about conditions that might affect the team's mission, taking over a key role such as automatic rifleman or team leader when casualties were assessed).

A fourth study compared squads who received critiques on coordination after training exercises to squads without such critiques. Live-fire performance was examined in an area that neither group had seen and that involved emergency situations. The number of hits achieved by the experimental squads was greater than that by the control squads. George concluded from this study that "if you want men to coordinate under the pressure of emergency events, you should train them to respond appropriately to such events" (p. 43). In addition, a high degree of intrasquad coordination requires training under emergency events and in rugged terrain, since such conditions force squad members to coordinate in a way similar to that in combat.

The training program recommended by George included three essential aspects: "(a) communication of coordination requirements to unit members, particularly information as to how coordination facilitates the accomplishment of unit goals, (b) practice on achieving typical unit goals despite unanticipated events that place unusually heavy requirements for coordination on unit members, and (c) feedback as to adequacy of performance, together with opportunity for further practice to correct errors, but with different events" (p. 44). Such training produces many of the coordinate responses that are ordinarily learned in combat, at great expense.

George, C.E. The view from the underside --- Task demands and group structure. In J.A. Olmstead, P.D. Hood, C.E. George, and T.O Jacobs (Eds.), Goal-directed leadership: Superordinate to human relations? (HumRRO Professional Paper 11-67). Alexandria, Va.: Human Resources Research Office, March 1967. (b) (DTIC No. AD 640 864)

See reference in Section B. George reviewed the studies of coordination within rifle squads cited in his 1967a paper.

George, C.E. Team member coordination: Definition, measurement, and effect on performance. Lubbock, Tex.: Texas Tech University. Paper presented at Southeastern Psychological Association meeting, New Orleans, La., March 1979.

George distinguished between two forms of coordination within teams: that which occurs as a result of a leader's order, and spontaneous coordination performed by members on their own initiative. The paper

focused on spontaneous coordination. Examples of such coordination within Infantry squads were given: fire team in the defense, team as base-of-fire element, and rifle squad attack. Although the study settings varied, most of the tasks presented to the squads required coordination. In general, coordination training improved the level of coordination that occurred in the initial trials. Coordination within control squads (without leaders) was low initially, but improved with time. The degree of coordination also correlated with squad performance.

George's model of teamwork hypothesizes that teamwork is a unit characteristic that develops under demanding training or operational conditions. Coordination responses, however, tend to be emitted very infrequently in leaderless groups or in situations where leader control is difficult, unless prior training on and reinforcement of coordinative behaviors has occurred. Such training requires the presentation of difficult tasks which demand spontaneous coordination and emphasis on the consequences of failure to coordinate.

Havron, M.D., Gorham, W.A., Nordlie, P.G., & Bradford, R.G. Tactical training of the infantry rifle squad (HumRRO Technical Report 18). Washington, D.C.: Psychological Research Associates, George Washington University, June 1955.

The first phase of the study compared four methods of training infantry squads (three experimental approaches and a control). At the end of this phase, the best elements of each of the training methods were combined into a composite program which was then evaluated using experienced and inexperienced instructors, and compared to previous data on Infantry squad performance.

In the first phase the control training procedure approximated current Army training doctrine. The three experimental procedures included the control method plus the particular experimental approach being evaluated. The group participation method stressed maximum participation of each squad member in the presentation and discussion of training material in order to develop group loyalty and esprit de corps. In the combat fundamentals method all tactical training was structured around seven basic principles which served as a frame of reference for all squad missions. The team training method stressed the duties of each member, employed a self-corrective system for performance of these duties, and used two teams within the squad to improve control and communication.

Two criterion measures were examined in both phases of the study: The Rifle Squad Field Test consisting of two attack, two defense, and two patrol missions, and the Leaderless Group Test consisting of an attack mission where the squad leader briefed his men on the attack but the squad leader and assistant leader were killed just before the squad left the line of departure, leaving the remaining squad members to carry out the attack. These tests had been used several years earlier to

examine the proficiency of the Army-trained squads and these results were used for comparison purposes.

The squad members were soldiers who had just completed 15 weeks of basic training. These members were matched up with squad leader candidates who were recent graduates of a six week Noncommissioned Officer Course. Soldiers were randomly assigned by race and Army General Classification Test scores to squads. Instructors were second lieutenants who had recently graduated from Officers Candidate School.

In the first phase eight squads were used in each of the three experimental programs and 16 squads were used in the control group. Results from these same 16 control squads were used in the second phase of the study as well. For the final composite training program, experienced instructors taught 32 squads and new instructors taught sixteen squads.

The composite training program used all of the combat fundamentals training, major parts of the team training method, and very little of the group participation method.

Results in phase two of the study showed no differences between the squads in the composite program that were taught by experienced and inexperienced instructors on either of the criterion tests. On the Rifle Squad Field Test, squads under the composite method were slightly better than the control squads (scores of 78% vs. 74%), but much higher than scores of 1952 and 1954 Army trained squads (scores of 63% and 56%). On the Leaderless Group Test squads trained with the composite method scored higher than the control squads (81% vs. 75%) and also showed less variability in performance. The strongest result was that all of the composite trained squads scored higher than the 1954 Army trained squads on the Leaderless Group Test (i.e., there was no overlap in performance for these two groups).

Recommendations for squad training were made. Of particular interest for team training was the researchers' discussion of small-unit organization and leadership. The Leaderless Group Test results showed that the composite trained squads performed much better after losing their leaders than did the Army trained squads. The authors attributed this difference to the fact that the "mutual interdependence of men and the responsibility of all for squad performance" was emphasized thorughout the training program. The men and the leader were encouraged to talk; to communicate. Procedures were developed so that individual members could integrate their individual task performance to the welfare of the entire unit. Thus when the leader was attrited, as often happens in combat, the remaining members were able to successfully continue the mission. A strong leader might not need to use such a "help" system, but he could. On the other hand, weaker leaders often profited from using such a system, thereby increasing the performance of the entire squad.

Havron, M.D. & McGrath, J.E. The contribution of the leader to the effectiveness of small military units. In L. Petruillo & B.M. Bass (Eds.), Leadership and interpersonal behavior. New York: Holt Rinehart & Winston, 1961, pp 167-178.

See reference in Section C1. A review of many Infantry squad training studies was provided. Factors such as training that stressed teamwork and the optimum size of the squad were examined.

Jacobs, T.O. Leadership in small military units. (HumRRO Professional Paper 42-69). Washington, D.C.: George Washington University, Human Resources Research Office, December 1968. (DTIC No. AD 682 340)

Development of a leadership training program for Infantry platoon leaders was summarized. Initial phases of the study involved determining behaviors of leaders in different kinds of situations (e.g., behaviors of platoon leaders when telling the entire platoon or part of the platoon about a new task; platoon leader behavior when reviewing tasks). The association between the frequency of such behaviors and rating of the platoon leader by his subordinates and superiors was also determined. Some of the behaviors that were identified describe "teamwork" activities that could be performed by either the platoon or squad leader. These behaviors were placed in six major categories: defining behaviors, pre-task motivation, post-task motivation, handling disruptive influences, getting information, and NCO use and support.

Jacobs, T.O., Rahn, R.C., & Moore, C.B. Instructor's guide: Basic problems in small-unit leadership. Fort Benning, Ga.: Human Resources Research Organization, Division No. 4, April 1965. (DTIC No. AD B000 670L)

This volume is the instructor's guide to the administration of the leadership course entitled, Basic Problems in Small-Unit Leadership, developed by HumRRO. Leadership areas covered were organizational context of leadership, setting platoon goals and standards, motivating performance, NCO use and support, and handling disruptive influence.

Kidd, J.S. Work team effectiveness as a function of mechanical degradation of the intrateam communication system. Journal of Engineering Psychology, 1963, 2, 1-14.

See reference in Section C1. The effects of interrupting communication within simulated air traffic control systems was examined, as well as techniques that could be used to off-set the resulting degradation in performance created by such interruptions.

O'Brien, R.E., Crum, W.J., Healy, R.D., Harris, J.H., & Osborn, W.C. <u>Trial implementations of the tank crewman skills training program (TCST)</u> (ARI Technical Report 78-A29). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978. (DTIC No. AD A061 226)

The report described the implementation of a modular, performance-based individual-paced tank crewman skills training program in five different situations: mobilization train-up of active and reserve crewman in a training center, mobilization train-up of training center crews, individual readiness training of armor crewman preparing for unit gunnery training, accelerated training of tank crew replacements, and accelerated refresher training of experienced crews deprived of regular gunnery training.

The authors concluded that the basic features of the training program were sound and should be recommended for any tank crew skills training program. These basic features are listed below and the first five could be applicable to other team training settings as well.

1. Individual readiness training should be individualized (because of the variation in entry level skills of trainees).

2. Individual readiness training should be performance based (training should begin with a pre-test and the individual should not be advanced until he demonstrates proficiency on a post-test).

3. Individual readiness training should be instructor managed (self-instruction does not mean self-management).

4. Individual readiness training should be closely tied to crew training requirements.

5. Individual readiness training should progress rapidly to crew readiness training (training should begin with team exercises, two-three-full-crew members, as soon as minimum qualification on individual skills is achieved; particularly important with short training times).

6. Maximum use should be made of dry and sub-caliber firing exercises.

A critical factor in a trainng program is the care with which it is implemented. Detailed guidance on how to plan, schedule, and deliver the training must be documented, validated, and provided with the program. Commitment of the commander to the program must also be obtained.

Prophet, W.W., & Caro, P.W. Simulation and aircrew training and performance. In Proceedings of the conference on aircrew performance in Army aviation. U.S. Army Research Institute for the Behavioral and Social Sciences, July 1974, pp. 130-136. (DTIC No. AD A001 539).

At the date of this report, the authors stated that "the use of simulation to study crew performance is virtually non-existent for Army aviation" (p. 131). The need to study such factors as the effects of workload, tasks, environmental stress, and allocation of crew duties within the simulator environment was mentioned.

Root, R.T., Hayes, J.F., Word, L.E., Shriver, E.L., & Griffin, G.R. Field test of techniques for tactical training of junior leaders in Infantry units (Project EFFTRAIN) (ARI Technical Report TR-79-A21). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.

The three purposes of the test were to compare the unit performance of an Infantry company trained with new tactical training techniques with a company trained with conventional combat training, to determine the relative value of "process" versus "product" performance measures in the measurement of unit proficiency, and to determine whether the new training techniques could be "handed off" to units with only written documentation. The experimental training package consisted of three distinct elements: gameboard training for platoon leaders and sergeants, field offensive and defensive exercises for leaders, and finally REALTRAIN exercises involving all men within the company. The comparison company established its own training program scheduled in accord with approved programs focusing on SCOPES training at the individual and unit level.

The criterion test consisted of six REALTRAIN exercises conducted as three offensive and three defensive engagements. Ratios of defending to attacking troops were sytematically varied from the typical 3 to 1 attack/defense ratio advantage of the defense in order to evaluate the experimental group against increasingly unfavorable odds. The experimental company won five to six exercises, inflicted almost twice as many casualties as did the comparison in both the defensive and offensive exercises, and used simulated mortar fire more effectively than the comparison company.

Analysis of the training sequence indicated that leader performance changed when moving from a gameboard setting to a field exercise (e.g., leaders abandoned complex tactical behaviors developed during game play until they could handle the basic elements of tactical performance under simulated conditions). The authors concluded that engagement simulation exercises without troops are required so that junior leaders can make "real-world" mistakes in tactical planning and execution before working in engagement simulation exercises with their troops. Improvements in "team" behavior/coordination were exhibited by the experimental company leaders during the gameboard and field exercises (p. 31): maintained

dispersion to avoid heavy losses due to indirect fire, exercised channels of communication and methods of control over terrain which often inhibited eye-to-eye contact, modified plans in reaction to spot intelligence reports. During the training exercises with the troops, individual skills and confidence improved for both leaders and troops and some team skills were developed (tactical movement and command/control; each soldier learned the importance of the chain of command and of the need to know details of the mission; when leaders became casualties soldiers were able to regroup/reorganize and continue the mission). "As the EFFTRAIN training program continued, the detailed refinements in procedures and automatic responses within squads and platoons were astonishing" (p. 32).

The authors concluded that documentation alone could not be used to introduce a training method such as EFFTRAIN. No direct evaluation of the contribution of each training component within EFFTRAIN could be made, but the authors concluded that each element made unique contributions and therefore was necessary. The entire program allowed individuals to develop clear ideas of not only how to function but also to understand why.

Schrenk, L.P., Daniels, R.W., & Alden, D.G. Study of long-term skill retention (NAVTRADEVCEN Technical Report 1822-1). St. Paul, Minn.: Honeywell, April 1969. (DTIC No. AD 503 679).

The purpose of the study was to investigate the long-term retention of team performance skills by Navy anti-submarine rocket (ASROC) teams. In the first phase of the study, training and testing materials were developed and evaluated. In the second phase, a comparison of three refresher training programs which used a team training device was made. Problems in interpreting the results arose from the many sources of uncontrolled variability in the study such as team turbulence, inability to control team training during nontest periods, and the initial ability of teams.

During the first phase of the study, parallel-form tests were developed for evaluation purposes. These tests were also scaled in difficulty. Sensitivity of the tests to retention effects was examined by comparing teams who varied in the amount of time since they had been trained on the team training device.

In the second phase, each group had team training on the training device followed by a posttest. One group then had one day of refresher training for the entire team eight weeks after the initial training, and was administered the retention test eight weeks after the refresher training. For the second group, the refresher training was only given to key personnel within the team. The third group, the control, received only the retention test at the end of the 16 week period. Each group consisted of approximately six ASROC teams. The major team performance measures were: number of weapons expended, probability of a hit, time to first shot, time to hit, and ratings of team performance by instructor personnel.

Differences among the experimental groups were not strong. The authors attributed this to the many uncontrolled variables in the study. However, they did conclude that full team refresher training was a more effective method of maintaining posttraining levels of team skills than was the key-person team refresher training. Observations also indicated that procedural skills, particularly those concerned with launcher malfunctions, sufferred the most severe degradation and contributed most to intra- and interteam variability.

Recommendations made by the authors that have applicability to other types of teams were as follows:

a. Substantial individual operator training should be accomplished prior to team training.

b. Subteams need to understand how their performance interacts with other subteams and influence total team performance.

c. Team training should be given on a periodic basis in order to insure retention of team skills.

d. The entire should participate in team training, including the appropriate officers who add leadership, stress, and motivation, and improve team cohesion.

e. Standardized training and evaluation materials should be used with team training devices.

Shriver, E.L., Jones, D.R., Hannaman, D.L., Griffin, G.R., & Sulzen, R.H. Development of small combat arms unit leader tactical training techniques and a model training system (ARI Research Report 1219). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.

The report summarized a series of activities conducted over a four-year period devoted to the development, revision, and evaluation of small unit leader training techniques that did not involve full troop support. Mapboard games and small unit leader field opposition exercises were developed, and most of the report documented the development process.

The authors found that the amount of teamwork required by a military unit varied with its mission; in particular, the attack and defense mission of the Infantry squad. "Much more leader subordinate interaction is required in offensive operations than in defensive operations. The leader must receive communications from his subordinates upon enemy contact; formulate new plans based on new intelligence; and communicate these new plans to the subordinates" (p. 14). The authors concluded that mapboard games played only by leaders did not provide adequate practice in the areas of leader/group interaction processes and communications. An appendix listed effective

and ineffective behaviors exhibited in field exercises, many of which reflected the existence of (or lack of) team skills during both mission planning and execution.

Siegel, A.I., & Federman, P.J. Communications content training as an ingredient in effective team performance. Ergonomics, 1973, 16, 403-416. (For earlier version of report, see Siegel, A.I., & Federman, P.J. Increasing ASW helicopter effectiveness through communications training (Technical Report: NAVTRADEVCEN 66-C-0045-1). Wayne, Pa.: Applied Psychological Services, October 1968. DTIC No. AD 682 498)

Two studies were reported. One focused on cross-validating previous research on the content of communications within anti-submarine warfare (ASW) helicopter crews. The other investigated the effects of communication training on ASW helicopter crew performance. Previous research on helicopter crews had shown that with increased training, communication transmission rates and the number of complete thoughts or ideas declined. Poorer team performance was associated with a lower ratio of complete thoughts to transmissions, representing inadequate exchange of information in such teams.

The first study attempted to cross-validate the content of communications within helicopter crews (pilot, copilot, sonar operator) and between two crews in a simulated ASW mission. The analytic framework for coding crew communications combined Bales interaction process analysis, Osgood's semantic differental technique, and some additional concepts developed by the research team. In the initial study approximately 30 communication variables were obtained, but the content analysis focused on the 14 that related to crew performance (i.e., miss distance). These variables were factor analyzed yielding four factors that were labeled and described as follows (p. 5-6):

Probabilistic structure: communications in which extrapolarative and data extensive communications occurred; reflected communications containing thought processes which involved the weighing of alternatives and the searching for answers to unresolved questions

Evaluative interchange: communications which contained direct requests for information and opinion, as well as the responses to these requests

Hypothesis formulation: communications involving interpretations of past performance in the mission and the evaluation of future tactics to be followed

Leadership control: communications marked by a role-coordinating attitude by the team leader, an attitude that served to define goals and to set a proper atmosphere for effective employment of the other factors

Data obtained in the cross-validation study indicated a strong relationship between frequency of communication within each of the communication categories and that obtained in prior research. Factor analysis of the communication data showed support for three of the previously identified factors: leadership control, probabilistic structure, and evaluative interchange.

The second phase of the study consisted of an evaluation of a team communications program. This program emphasized case discussion and role playing techniques, lasting from 13 to 16 hours. Crews receiving the communications training were compared to crews without such training. Unfortunately, it was not possible to randomly assign crews to conditions, and the crews in the control condition were the more experienced personnel. Each group consisted of four teams (that is, eight crews), for a total of 16 pilots.

Simulator data indicated that the trained group performed better (number of correct attacks) that the control group, without loss of time and navigational accuracy. In addition, differences were found in the communications content of the ten groups. In terms of absolute frequency counts, the trained group had 1.5 times as many leadership control communications, 2.2 times as many evaluative interchange communications, 2.3 times as many hypothesis formulation communications, and 4.1 times as many probabilistic structure messages. The relative frequency of these communication categories also differed, with probabilistic structure constituting 22% of the communications within the trained group and 11% within the control group, and leadership control being 41% in the trained group and 60% in the control. For the trained group leadership control meant encouraging an interchange of opinion and information; for the control group it reflected a tighter and more autocratic leadership structure. The authors hypothesized that the differences in communication between the two groups may have accounted for the differences in crew performance.

Thurmond, P. & Kribs, H.D. <u>Computerized collective training for teams. Final report</u> (ARI Technical Report TR-78-A1). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, February 1978. (DTIC No. AD A050 890)

The purpose of the study was to demonstrate and evaluate a brassboard for computerized collective training for teams, called $COLT^2$. The team studied was the Army computerized artillery fire control system (TACFIRE).

The authors reviewed literature applicable to developing strategies for computer-assisted team training. Specific issues discussed were: definition of team, distinction between emergent and established team tasks, serial vs. parallel team structure, team instructional strategies, team task dimensions, learner characteristics and learner strategies relevant to team performance, and computer assisted instructional capabilities. Three major team task dimensions were identified: knowledge of team roles (including self-evaluation skills

and team awareness), team attitudes (confidence, pride, and aggressiveness), and team communication (probabilistic structure, evaluative interchange, hypothesis formation, and leadership control).

A detailed job/task analysis was conducted. Each team member act was broken into three parts: input (signal/stimulus that elicits behavior), processes or response, and output (signal/stimulus resulting from the process). The linkage between acts was indicated, yielding team-task flow diagrams. Each task/subtask was also classified as serial and/or parallel, and by the team dimensions required. Fire mission training scenarios were then developed which were sequenced by complexity and teamwork required: individual training, beginning team training, integrated team training, and emergent team training.

The above procedures were based upon a team instructional system design (ISD) model. The ISD model had the following deficiencies: inadequate methodology for preparing, analyzing, and categorizing team learning objectives; inadequate evaluation design to address team member interactions as well as individual and team achievement; and no incorporation of relevant findings from small group behavior research into the conceptual framework for instructional strategies. Information from a comparison of instructional strategies was limited due to the small sample size. Recommendations were made regarding improvement of CAI software for team instruction.

BESRL (U.S. Army Behavior and Systems Research Laboratory) Studies on Image Interpretation.

A series of studies conducted by BESRL investigated using team training to enhance individual performance. In particular, these studies developed and tested the team consensus feedback method as a technique for maintaining and enhancing the proficiency of individual image interpreters (individuals who must extract information from surveillance displays). The essential feature of the training procedure was that interpreters practiced in teams, arriving at decisions with regard to target detection and identification by a consensus of team members.

On actual missions, image interpreters work alone and are often unaware when they are doing a poor job. If they do receive feedback, it is often too late to be effective. In team training, however, interpreters were forced continually to examine themselves, since their teammates found targets and made identifications that disagreed with their own. This awareness of disagreement forced the team members to take a hard look at the target and also allowed less proficient interpreters to become aware of some of their own deficiencies and to learn from the more proficient interpreters.

The research approach used in these studies differs from the usual study of the transfer of individual skills to the team situation. Factors varied in the program included delay of feedback, the manner in which the feedback was presented, type of feedback, size of team,

composition of teams in terms of initial proficiency of team members, and the effect of initial proficiency on subsequent learning. Results showed that team consensus feedback was an effective method in enhancing individual skills. The following studies are some that have been conducted under the BESRL image interpretation program (listed in chronological order).

Bolin, S.F., Sadacca, R., & Martinek, H. Team procedures in image interpretation (Technical Research Note 164). Washington, D.C.: U.S. Army Personnel Research Office, December 1965. (DTIC No. AD 480 533).

Doten, G.W., Cockrell, J.T., & Sadacca, R. The use of teams in image interpretation: Information exchange, confidence, and resolving disagreements (Technical Research Report 1151). Washington, D.C.: U.S. Army Personnel Research Officer, October 1966. (DTIC No. AD 643 312).

Cockrell, J.T. Maintaining image interpreter proficiency through team consensus feedback (BESRL Technical Research Note 195). Washington, D.C.: U.S. Army Behavioral Science Research Laboratory, April 1968. (DTIC No. AD 833 583).

Doten, G.W., & Sadacca, R. Team interpretation procedures: Selection of teammates and role assignment (BESRL Technical Research Note 201). Arlington, Va.: U.S. Army Behavioral Science Research Laboratory, January 1969. (DTIC No. AD 688 140).

Cockrell, J.T. Maintaining target detection proficiency through team consensus feedback (BESRL Technical Research Note 219). Arlington, Va.: U.S. Army Behavioral Science Research Laboratory, December 1969. (DTIC No. AD 707 376).

Cockrell, J.T., & Sadacca, R. Training individual image interpreters using team consensus feedback (BESRL Technical Research Report 1171). Arlington, Va.: U.S. Army Behavioral and Systems Research Laboratory, June 1971. (DTIC No. AD 747 827).

The Ohio State University Combat Information Center Studies.

A series of seven studies was conducted by Briggs and his colleagues on radar control aircraft intercept problems similar to the tasks encountered by Combat Information Center (CIC) teams on Navy ships. One major goal of these studies was to examine the relative importance of team versus individual training as the required degree of interaction among team members increased.

The teams within each study were composed of two radar controllers and one supervisor. The mission of the team was to intercept approaching enemy aircraft with friendly aircraft. The major criterion variable was the amount of fuel consumed per hit (primarily a measure of individual skill as indicated in the Briggs and Johnston report). Four

training sessions and four transfer sessions were given, with each session lasting about 50 minutes. Teams were composed of college students.

The following report is the first report in the three-report series. See also the Briggs and Johnston (1967) reference in Section A.

Briggs, G.E., & Naylor, J.C. Experiments on team training in a CIC-type task environment. (Technical Report, NAVTRADEVCEN 1327-1). Columbus, Ohio: Ohio State University, Laboratory of Aviation Psychology, June 1964. (DTIC No. AD 608 309)

Experiment I examined three independent variables in a factorial design: task organization (radar controllers worked independently of each other or interacted with each other to trade-off targets), task complexity (two dimensional task where aircraft speed and heading were controlled versus a three dimensional task where aircraft altitude was also controlled), and the relative amount of training received by replacement controllers (categorized as high and low). In the independent task organization condition, a panel was placed in the middle of the target area to separate the two radar controllers which made it impossible for the controllers to see or communicate with each other. Target trade-offs were handled automatically by the supervisor. In the interactive situation, the panel was removed and each radar controller could make a decision when and if to trade-off a target. The three dimensional task was more difficult than the two dimensional task, performance improved with time, and on the last transfer session the independent task organization condition was better than the interaction condition.

A separate report of Experiment I can be found in:

Naylor, J.C., & Briggs, G.E. Team-training effectiveness under various conditions. Journal of Applied Psychology, 1965, 49, 223-229.

Experiment II also examined three independent variables within a factorial design: interactive versus independent training task organizations, interactive versus independent transfer task organizations, and high versus low degrees of training task fidelity (the amount of verbal interaction required between the radar controllers was varied). Within the four combinations of training and transfer task organization the interactive-interactive sequence produced the lowest level of performance during the transfer session; the other three training-transfer combinations produced similar levels of performance. Fidelity of training interacted with transfer task organization; within low fidelity the independent task organization yielded better performance than the interactive organization while the reverse was the case within the high fidelity condition.

A separate report of Experiment II can be found in:

Briggs, G.E., & Naylor, J.C. Team versus individual training, training task fidelity, and task organization effects on transfer performance by three-man teams. Journal of Applied Psychology, 1965, 49, 387-392.

Experiment III examined two training conditions that differed in the relative amount of interactive and idnependent training and also compared independent and interactive transfer task settings. No significant differences occurred.

The authors concluded from these three studies that individual rather than team training is a preferred procedure especially for operational tasks organized for interaction among operators on team members. However, interactive training was facilitating when it occurred under high as opposed to low fidelity conditions. (Note. - The task used in these studies was not a "team" task in that it could be performed by operators acting independently of each other.)

Briggs, G.E., & Johnston, W.A. Team training research (Technical Report NAVTRADEVCEN 1327-2). Columbus, Ohio: Human Performance Center, Ohio State University, November 1965. (DTIC No. AD 477 963)

In this report by Briggs and Johnston on Combat Information Center (CIC) teams, the transfer task required more interaction and coordination among the radar controllers than that required in the Briggs and Naylor report. In these studies each controller had to coordinate the attack of his two aircraft interceptors with that of the two interceptors controlled by the other controller. Fuel consumed per hit was viewed as a measure of individual skill. Another measure, degree of coordination, was developed to measure team skill and reflected the distance of an interceptor from his target when the other radar controller made a hit with his interceptor.

Experiment IV examined two independent variables in a factorial design: the stimulus fidelity of the training task to the transfer task and the response fidelity of the training task. No significant differences occurred on the fuel per hit measure, but coordination was higher upon transfer for those teams trained under high fidelity conditions, particularly, high stimulus fidelity.

A separate report of Experiment IV can be found in:

Briggs, G.E., & Johnston, W.A. Stimulus and response fidelity in team training. Journal of Applied Psychology, 1966, 40, 114-117. (c)

Experiment V compared five training settings that varied both the amount of team member coordination and communication required. The transfer task required both team coordination and communication. One important variation was a condition that required a controller to coordinate his two interceptor aircraft with each other, but did not

require him to coordinate his aircraft with those of the other controller.

On the transfer task, no differences occurred on the individual skill measure of fuel consumed per hit. On the other hand, those teams where the controllers were trained to coordinate their two interceptor aircraft, either with each other or with the aircraft of another controller, scored higher on the coordination measure. The researchers concluded that another way of interpreting the results was that the coordination groups received high fidelity training, whereas the noncoordination groups received low fidelity training.

A separate report of Experiment V, including additional analyses of the content of verbal comunication between the radar controllers, can be found in:

Johnston, W.A. Transfer of team skills as a function of type of training. Journal of Applied Psychology, 1966, 50, 102-108.

The final conclusions regarding the relative importance of team and individual training derived from the series of studies were as follows. If no or little interaction is required to perform the operational task, then individual training is best. If a substantial amount of interaction is required (similar to that in Experiments IV and V), then individual and team training procedures will be equally effective. If an even higher level of interaction is required, then team training will probably be best. Before determining the amount of individual and team training to be provided for a specific task, a careful analysis must be made of the kind and degree of interaction required of the team members. Such an analysis will require an objective, quantitative scale of intermember interaction. More complex experimental designs will be required in the future and the emphasis upon observation will become more complex.

Briggs, G.E., & Johnston, W.A. Laboratory research on team training (NAVTRADEVCEN 1327-3). Columbus, Ohio: Ohio State University, May 1966. (b) (DTIC No. AD 485 636)

The third report in the series focused on the effect on team behavior when evaluation criteria are changed and on whether team communication facilitates performance when alternate means of obtaining task-relevant information are not available. The team task was basically the same as that used in Experiments IV and V described in the preceding report.

In Experiment VI a transfer of training paradigm was used. During training, each radar controller of the CIC team had to coordinate his own two interceptors, while during transfer each controller had to coordinate with the other controller.

In this experiment two criteria were examined: time to make an interception and amount of separation between a nonintercepted target

and its assigned interceptor. It was assumed that these two criteria were incompatible in that it would be very difficult to maximize performance on both simultaneously. The experimental design compared eight treatments that varied on the criterion stressed during the training and transfer periods. Four treatments examined a simple-to-simple situation where only one criterion was stressed during both training and transfer periods (however, the specific criterion could differ at these two time periods). Four simple-to-complex situations were examined where a single criterion was stressed during training and two criteria (time and separation) were stressed during transfer. Throughout training and transfer sessions the teams received performance feedback. Results showed the teams adjusted easily when transferring from one simple criterion condition to another, but when changing from the simple to complex, incompatible criteria condition the effects of earlier training on a simple criterion persisted.

In Experiment VII various combinations of visual and verbal communication channels were allowed between the two radar controllers during training and transfer. In this study the work load was half that of Experiment VI, each controller had to coordinate his behavior with the other controller during training and transfer, and only the separation criterion was stressed.

Results showed that the verbal only channel condition was inferior to conditions allowing both verbal and visual communication and to conditions allowing only visual communication between controllers. Comparison of the later two conditions showed that adding the verbal to the visual channel did not improve performance beyond that achieved with visual communications only. Content analysis of verbal communication indicated that tactical communication messages facilitated performance, but that controllers used these at a low rate. Even teams that had to rely solely on verbal communication throughout training and transfer conditions did not increase their use of this type of communication. The authors suggested that training in efficient verbal coding might improve task performance.

Final recommendations from the two experiments were that "if complex criteria are found in the evaluation of performance in the operational context, then training should utilize the same complex criteria to facilitate team performance which will be judged acceptable in the operational systems" (p. 27), and that "if other system information channels contain sufficient information for succesful team performance, the presence of a channel for verbal interaction between team members not only may add nothing to team performance but even may result in less proficient performance. It is recommended, therefore, that whereas a verbal information channel may be used as a backup to more efficiently coded information channels, such a verbal channel should be restricted under normal conditions to the transmission of only essential and simple information" (p. 27-28).

U.S. Army Research Institute (ARI) for the Behavioral and Social Sciences Studies on Training Military Units using REALTRAIN.

The Army Research Institute conducted a series of studies on the effectiveness of REALTRAIN, a set of procedures and equipment designed to make small unit (i.e., generally at the company level and below) tactical field exercises more like real combat. During a two-sided engagement, real-time casualty assessment methods are employed for both direct and indirect fire weapons, including hand grenades and claymore mines. For example, with rifle squads, squad members have numbers placed on their helmets. Casualties occur when an opposing player can identify this number through a 6 power telescope on the player's M16 rifle, as verified by a controller. Casualty information (time, killer and victim player numbers, etc.) are then relayed by radio to a control station. Training procedures for mechanized forces have also been developed. After-action reviews that focus on major incidents during the mission, and on both individual and unit performance are an integral part of the training program.

The first study described early work on REALTRAIN. The next five studies examined the effectiveness of REALTRAIN with rifle squads and with armor/anti-armor teams. These studies also examined the tactical performance of these teams and demonstrated the role of "teamwork" in determining mission success. The last three studies examined the effect of REALTRAIN on team motivation.

Root, R.T., Epstein, K.I., Steinheiser, F.H., Hayes, J.F., Wood, S.E., Sulzen, R.H., Burgess, G.G., Mirabella, A., Erwin, D.E., & Johnson, E. Initial validation of REALTRAIN with Army combat units in Europe (ARI Research Report 1191). Arlington, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, October 1976. (DTIC No. AD A034 610).

The purpose of the study was to examine the effectiveness of REALTRAIN, determine ways of improving REALTRAIN, and improve methods of assessing unit tactical performance. Two types of exercises were used: meeting engagements and attack/delay situations with the force ratio being 1 to 1 in all exercises. A tank platoon, two infantry squads and a TOW section were on each side. Some of the units conducted REALTRAIN exercises for three weeks; the other units rotated every week.

Training with REALTRAIN increased the effectiveness of the units: REALTRAIN units won 48% of the engagements, other units won 12%, the remaining engagements were ties; REALTRAIN units suffered fewer vehicular and personnel casualties; and REALTRAIN participants and controllers liked the system, citing its realism, the learning opportunities in combined arms operations, cross-training, development of battlefield confidence and teamwork in tactical maneuvers. Suggestions for improving REALTRAIN exercises were given.

Banks, J.H., Hardy, G.D., Scott, T.D., Kress, G. & Word, L.E. REALTRAIN validation for rifle squads: Mission accomplishment (ARI Research Report 1192). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, October 1977. (DTIC No. AD A043 515).

In this study conventional rifle squad training was compared with training using REALTRAIN procedures. Rifle squads were given a tactical pre-training test, three days of training using either REALTRAIN or conventional methods, a post-training test, and finally a series of tactical exercises in which REALTRAIN and conventional squads opposed each other. There were nine nine-man squads within each training condition. Indirect fire was not employed.

Results on both hasty defense and movement to contact missions indicated that the REALTRAIN procedure was more effective than conventional training in terms of mission accomplishment, number of casualties inflicted. In addition, conventionally trained squads showed little or no improvement from pre- to posttest.

Meliza, L.L., Scott, T.D., & Epstein, K.L. REALTRAIN validation of rifle squads II: Tactical performance (ARI Research Report 1203). Alexandria, Va.: U.S Army Research Institute for the Behavioral and Social Sciences, March 1979.

The data for this report were obtained from the Banks et al. study (1977). However, this report focused on the tactics used by the squads during both the REALTRAIN and conventional exercises, and the relationship between those tactics and squad success.

REALTRAIN squads performed better than conventionally trained squads in the movement to contact mission in several ways: used cover and concealment more effectively, were more likely to use overwatch, were more likely to use suppressive fire, were more likely to use the M60 machine gun to cover their maneuvering element, used hand grenades more effectively, were more likely to attack the more vulnerable approach to the enemy's observation post, were more likely to be actively controlled by a leader, and were more likely to perform as an integrated unit (p. 4). Some of these differences between the two groups could be attributed to differences in teamwork. For example, the authors stated that two of the conventionally trained squads failed to use the M60 because the machine gunner was an early casualty and the assistant gunner was unable to assume his role, while in a third squad the assistant had all the ammunition but became separated from the machine gunner. REALTRAIN squads had leaders who were in relatively constant communication with the squad, took an active role in directing its activities, had designated another squad member to assume command if he were declared a casualty, and squad members were responsive to the leader's commanders. Lead fire teams within the REALTRAIN squads worked as integrated units in that if some members moved forward other team members would support them by fire or conceal their advance with smoke grenades, and internal communication was maintained. The correlation

between squad scores on these tactical behaviors (called process measures by the authors) and squad success (i.e., ratio of enemy to friendly casualties) was .60.

Tactical differences were also found in the hasty defense mission. REALTRAIN squads, as compared to conventionally trained squads, were more likely to use an observation post, to deploy to cover their more vulnerable flank, to place claymore mines to cover the most likely route of enemy advance, to make early detections of the enemy, and to open fire before the enemy did so (p. 5). Squad scores on these process measures correlated .63 with mission outcome (i.e., ratio of enemy to friendly casualties).

Scott, T.D., Meliza, L.L., Hardy, G.D., Banks, J.H., & Word, L.E. REALTRAIN validation for armor/anti-armor teams (ARI Research Report 1204). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, March 1979.

REALTRAIN engagement simulation procedures for armor/anti-armor teams were compared to conventional field training procedures. The tested units involved eight tank platoons with attached TOW antitank weapon and forward observer sections. The training-testing sequence was as follows: ARTEP (Army Training and Evaluation Program) based pretraining test to establish entry-level proficiency, five days of training with either REALTRAIN or conventional training, posttraining test conducted to determine performance changes resulting from training, and finally a two-sided free-play exercise in which REALTRAIN and conventionally trained units opposed each other. In the posttraining test, the experimental units participated in both defense and attack scenarios against an opposing force that had been given two weeks of tactical and scenario-specific training.

Results of the posttraining test indicated that REALTRAIN units performed better than conventionally trained units in that they accomplished more missions, sustained fewer casualties particularly in early phases of the attack, inflicted more casualties, and were detected less often by the opening force. In the shoot-off exercises between REALTRAIN and the conventionally trained units, the REALTRAIN units won in six out of seven meeting engagements, sustained fewer casualties, and inflicted more casualties.

Scott, T.D., Meliza, L.L., Hardy, G.D. & Banks, J.H. Armor/anti-armor team tactical performance (ARI Research Report 1218). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.

This report described the tactical performance of successful and unsuccessful armor/anti-armor units during the attack mission of the REALTRAIN validation study described above in the Scott et al. (1979) report. During the early phase of the attack mission, i.e., before the withdrawal of the opposing force's (OPFOR) observation post (a TOW section), the successful units were more effective in planning the

attack, initial deployment of their vehicles, use of cover and concealment, surveillance, and use of firepower.

Many of the positive actions taken by the successful units reflected varying degrees and types of teamwork. For example, early planning was lacking in the unsuccessful units, in that in 41% of these units the tank and TOW crews were not briefed on the contents of the platoon leader's orders, compared to 17% of the successful units. Since many of the unsuccessful units lost their leaders early, their crews had inadequate information on how to proceed. Successful units planned to provide protection for their maneuvering elements as they crossed the line of departure and to provide continuing overwatch for maneuvering tanks to a greater extent than unsuccessful units. Unsuccessful unit vehicles were more likely to be observed by more than one OPFOR crew than successful unit vehicles, suggesting that unsuccessful units may not have been maintaining adequate dispersion among their vehicles. Successful units were more likely to dismount crews in order to employ crew members forward in observation posts, thereby minimizing vehicle detection by the OPFOR observation post. Successful units also planned for and made better use of their TOWs, dismounting one and leaving one mounted, providing both mobility and TOW survivability. Indirect fire was employed by the successful units before the OPFOR TOW withdrawal in order to suppress the OPFOR or to conceal their own movements by smoke screens. The correlation between the number of appropriate tactical behaviors exhibited by the units and mission success/failure was .77.

Scott, T.D. Tactical training for ground combat forces. Armed Forces and Society. 1980, 6(2), 215-231.

Mission accomplishment and casualty exchange ratios were compared for Infantry squads and armor/anti-armor units trained with REALTRAIN and conventional techniques. Both training groups performed poorly on pretest measures. Tactical superiority of REALTRAIN units after training was shown on both types of measures. Conventionally trained units performed particularly poorly in the early force engagements. The problem with REALTRAIN is not its training effectiveness, but its implementation (personnel support and equipment) within Army units.

Sulzen, R.H., & Bleda, P.R. Effects of combat simulation on the work-related motivation/satisfaction of participants (ARI Technical Paper 351). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, March, 1979.

The data for this report were also based on the Banks et al. (1977) study. Squad members in both the REALTRAIN and conventionally trained conditions were given pre- and post-measures of job-related motivation and satisfaction. On four of the six motivation dimensions (attitude toward the exercises, military work role, unit cohesiveness, and leader improvement), REALTRAIN squads scored higher after the training than before. Conventional training, however, did not positively influence any of the work-related dimensions, and had a depressing effect on one dimension (leader improvement).

Bleda, P.R., & Hayes, J. Impact of REALTRAIN and conventional combined arms exercise on participant morale (ARI Technical Paper 308). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1978.

Armor and Infantry personnel were exposed to one-week of REALTRAIN or of conventional ARTEP (Army Training and Evaluation Program) exercises. A series of attitude/morale questions were administered to half the personnel before the training exercises; the remaining personnel were given the attitude questions after training. The questions were designed to measure motivation before (or satisfaction after) training as well as general job satisfaction and unit cohesiveness. Units with REALTRAIN exercises indicated improved levels of satisfaction after training, while those undergoing conventional ARTEP exercises indicated similar or lower levels of satisfaction. One of the factors that may have affected the results was that the REALTRAIN exercises were conducted at the platoon level while the conventional exercises were apparently conducted at either the company or the battalion level. The authors mentioned that higher-echelon exercises provide less opportunity for line troops to train than do lower-level platoon exercises.

Bleda, P.R., & Sulzen, R.H. The effects of simulated Infantry combat training on motivation and satisfaction. Armed Forces and Society, 1980, 6(2), 202-214.

A comparison was made of job-related satisfaction and motivation in Infantry squads that had been trained with REALTRAIN techniques to those squads trained by conventional techniques. REALTRAIN forces improved significantly on four of six motivation/satisfaction dimensions while conventionally trained forces decreased in one dimension. Changes in REALTRAIN units were strongest on those dimensions directly related to training itself - value of training exercises for individual soldiers and leaders.

U.S. Army Research Institute of Environmental Medicine (USARIEM) Studies on Sustained Operations within Field Artillery Fire Direction Centers.

Stokes, J.W., & Banderet, L.E. A war for science. Field Artillery Journal, 1978, Jan-Feb, 42-44.

Banderet, L.E., & Stokes, J.W. Interaction process analysis of FDC teams in simulated sustained combat. (Paper presented at a NATO symposium on motivation and morale in Brussels, Belgium). Natick, Mass.: U.S. Army Research Institute of Environmental Medicine, September 1980. (a)

Banderet, L.E., & Stokes, J.W. Simulated, sustained-combat operations in the Field Artillery Fire Direction Center (FDC): A model for evaluating biomedical indices. Proceedings of the Army Science Conference, 1980, 1, 167-181. (b)

Banderet, L.E., Stokes, J.W., Francesconi, R., Kowal, D.M., & Naitoh, P. Artillery teams in simulated sustained combat: Performance and other measures. In L.C. Johnson, D.I. Tepas, W.P. Colquhoun, & M.J. Colligan (Eds.), Variations in work-sleep schedules: Effects on health and performance. Advances in Sleep research, Vol. 7. New York: Spectrum Publications, in press.

The four papers listed above describe various aspects of a major study on simulated, sustained combat operations in the Field Artillery Fire Direction Center (FDC). The study design consisted of two treatments with two FDCs per treatment. In treatment 1, the FDCs had a single 86 hour operational challenge; in treatment 2, the FDCs had two 38 hour challenges separated by a 34 hour rest interval. Both treatments had identical, pre-challenge familiarization and training trials. Each team was composed of five individuals who volunteered for the study. Each FDC was exposed to a combat scenario that required the FDC to fire suppression, immediate suppression, and targets of opportunity missions, many simultaneously. Other missions such as smoke, high-angle, time-on-target, ICM (improved conventional munitions), and illumination were requested. Each day the FDC had to move four times, receive eight GFT (graphical firing table) updates from battalion, compute data for 400 pre-planned targets, and execute 100 priority target changes.

A detailed description of the results is not presented here. However, teams/treatments were compared over time on such variables as number of hours the team continued with the simulation, accuracy of output, timeliness of output, preplanning and prioritizing latencies, unprocessed preplanned target demands, content of verbal interaction during lull periods, performance by individual members on position tasks, and physiological measures including oxygen uptake, heart rate, and various urine analyses.

The initial 36 hours of the 86 hours single sustained operations treatment were found to be more demanding than equivalent points during the two 38 hours repeated challenges condition. Performance deteriorations occurred earlier and were greater. The authors attributed part of this decline to the implied mission demands, self- and team-doubts, and uncertainties associated with the 86 hour challenge. Results also indicated that the FDC's ability to handle the preplanned missions decreased with time, creating increased work loads and pressure, and leading to more inaccuracies, greater latencies, and an increased volume of incompleted missions. This situation was particularly true for the team composed of the least experienced individuals.

Note. - The complexity and duration of the "team task" in this study contrasts sharply with other team research. Many additional variables that can affect team performance enter the picture, e.g., simultaneous tasks, increased number of incompleted tasks, team's ability to handle errors under stress and fatigue. The paucity of such studies suggests

that researchers may have only minimal understanding of the factors affecting real-life team performance.

E. TEAM TRAINING STUDIES

2. Training Guidelines

Team training guidelines and general recommendations for developing and implementing training programs are presented in the articles in this section. Such principles are based on both team and small group research.

1. General Guidelines

Boguslaw & Porter (1962)
Defense Science Board (1976)
Kress & McGuire (1979)
McGuire & Kress (1980)
Schrenk, Daniels & Alden (1969)
Shriver et al. (1980)

2. Specific Techniques/Procedures to Stress during Team Training

Boguslaw & Porter (1962)
George (1967a)
HumRRO (1970)
Jones & Odom (1954)
Kraemer & Kristiansen (1979)
Shriver et al. (1979, 1980)

3. Sequencing of Individual and Team Training

Daniels et al. (1972)
Kraemer & Kristiansen (1979)
O'Brien et al. (1978)

4. Managing Turnover in Team Personnel

Morgan et al. (1978)

5. Use of Feedback

Briggs & Johnston (1967)

6. Training Individuals with Varying Abilities

Bialek, Taylor & Hauke (1973)

7. Procedures for Generating Training Guidelines

Caviness & Titus (1977)
Dyer (in press)

Bialek, H.M., Taylor, J.E., & Hauke, R.N. Instructional strategies for training men of high and low aptitude (HumRRO Technical Report 73-10). Alexandria, Va.: Human Resources Research Organization, April 1973.

The report described a series of studies that used various instructional approaches for high and low aptitude soldiers. High aptitude individuals were those with an Armed Forces Qualification Test (AFQT) score from 90 to 100 (Category I); low aptitude individuals were those with an AFQT score from 10 to 30 (Category IV). Although only

individual tasks were studied, the lessons learned may have some implications for team training. Examples of the individual tasks are message authentication, military time, target location, field wire splicing, map reading, setting up switchboard, distance measurement, and using a compass.

Some of the instructional procedures used with the low aptitude soldiers were small group instruction, video-tape presentations to a group with instructor assistance and prompts, peer instruction, videotape with no feedback, and self-instructional booklet. The success of these various methods varied with the task presented; some methods failed on all tasks. The overall conclusion was that procedures that maximized personal interaction during instruction were more effective, took less time, and were cheaper than techniques without such interaction.

In general, the techniques successful with the highest aptitude individuals failed with the low aptitude group. With high aptitude individuals, minimal guidance was required, self-instructional booklets could be used, fewer practice problems and examples were given, and instructors acted simply as class monitors and test administrators. These individuals also created a great deal of peer pressure among themselves to do well on the tasks; pressure that was not characteristic of low aptitude individuals.

Boguslaw, R., & Porter, E.H. Team functions and training. In R.M. Gagne (Ed.), Psychological principles in systems development. New York: Holt Rinehart & Winston, 1962, pp. 387-416.

See reference in Section A. Team training should consider the following factors: orientation to team goals, training in interdependencies, training for error analysis, training for sensing overload, training in adjustment mechanisms, and training for emergent situations. These areas are in addition to training each man in his individual position.

Briggs, G.E., & Johnston, W.A. Team training (Technical Report: NAVTRADEVCEN 1327-4). Columbus, Ohio: Ohio State University Human Performance Center, June 1967. (DTIC No. AD 660 019)

See reference in Section A. The authors stressed the importance and role of debriefings: can be used to explore alternative ways of organizing the task to enhance team performance as well as examining individual performance. Adequate time must be allowed for such debriefings, particularly with relatively large teams in complex situations. The use of knowledge of results in such sessions was discussed in some detail. Turbulence in team members seems to have less effect upon team performance if replacement personnel are well trained.

Caviness, J.C., & Titus, T.L. KC-135 aircrew management. Maxwell Air Force Base, Ala.: Air University, May 1977. (DTIC No. AD B020 444L)

Suggestions for assisting new aircrew commanders were given, based on the experiences of the authors (19 years K-135 aircrew experience, 6,600 hours in the aircraft, and 7.5 years as aircrew instructors). One section of the document was devoted to training, including crew coordination. The authors described crew coordination as requiring each member being proficient in his own duties and also understanding the duties of the other members so that he can notify them of flight problems. Suggestions for improving crew coordination included mission planning, post mission critiques, training situations that simulate emergency conditions, and conducting all training exercises as though they were being formally evaluated so that crew members do not develop bad habits.

Daniels, R.W., Alden, D.G., Kanarick, A.F., Gray, T.H., & Feuge, R.L. Automated operator instruction in team tactics (NAVTRADEVCEN 70-C-0310-1). St. Paul, Minn.: Honeywell, January 1972. (NTIS No. AD 736 970)

See reference in Section A. The authors recommended the following sequence of individual and team training: individual skill training first, followed by training with an assembled team to stress interaction, coordination, and development of a sense of team awareness, with tactical team training dealing with uncertain, ambiguous or emergency situations as the last training stage. Six steps in designing an effective training system were outlined: task and function analysis, training requirements analysis, training program development, training device design, training program and evaluation, and training program revision.

Defense Science Board, Summary report of the task force on training technology. Washington, D.C.: Office of the Director of Defense Research and Engineering, 1976. (See also, Alluisi, E.A. Lessons from a study of defense training technology. Journal of Educational Technology Systems, 1976, 5, 57-77).

Part of the Defense Science Board's report focused on the need to increase research funds for training technology research and development in support of crew/group/team/unit training. Despite the fact that most military training is applied in the operational context of crews, groups, teams, and units, this type of training generally does not fall within the scope of military training organizations and training technology has generally not been applied to such operational situations. The Board concluded that application of developments in training technology would lead to more efficient and effective crew/group/team/unit training.

Dyer, J.L. Prediction of Infantry squad errors during training: Pilot investigation (ARI Technical Report). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, in press.

Individuals with previous company command experience were asked to predict the errors made by rifle squads during MOUT (military operations in urbanized terrain) exercises based on a written description of the training setting. Although experienced individuals could predict errors made by squads, the overlap among the predictions was not high. Actual and predicted errors reflected both individual and squad mistakes.

Documentation of such predictions could provide useful training requirement information to incoming commanders and trainers, and serve to provide continuity and maintain quality in training despite turnover in training personnel. Further modifications of and additional training questions that should be addressed with the procedure were suggested.

George, C.E. Training for coordination within rifle squads. In T.O. Jacobs, J.S. Ward, T.R. Powers, C.E. George, & H.H. McFann (Eds.), Individual and small-unit training for combat operations (HumRRO Professional Paper 21-67). Alexandria, Va.: Human Resources Research Office, George Washington University, May 1967. (a) (DTIC No. AD 653 845)

See reference in Section E1. The training program recommended by George after a series of studies on Infantry squad training stressed three points: "(a) communication of coordination requirements to unit members, particularly information as to how coordination facilitates the accomplishment of unit goals, (b) practice on achieving typical unit goals despite unanticipated events that place unusually heavy requirements for coordination on unit members, and (c) feedback as to adequacy of performance, together with opportunity for further practice to correct errors, but with different events" (p. 44). George concluded that such training would produce many of the coordinate responses that are ordinarily learned in combat, at great expense. Although these recommendations were derived from studies of Infantry squads, they are applicable to all teams.

HumRRO. Training for small independent action forces (SIAF). Alexandria, Va.: Human Resources Research Organization, HumRRO Division No. 4, Fort Benning, Georgia, undated (about 1970).

This reference refers to a series of 27 documents that were prepared for the training of small independent action force (SIAF) personnel. Such forces conduct independent operations in insurgency environments. It was assummed that personnel entering SIAF training would have basic combat training and advanced individual training for infantryman (or their equivalents). The approach used in the SIAF program was to analyze predicted operational missions for SIAF units including organization, tactics, equipment and personnel. System analytic techniques were used to specify required activities of SIAF personnel. Performance requirements were then determined, and systems engineering

procedures used to derive training objectives and training materials for accomplishing the objectives. In all the training materials, cross-training, overlearning, pre-team sensitization, and practical exercises were stressed as a means of increasing both individual and team proficiency. The importance of teamwork was stressed throughout.

The contents of the SIAF volumes are listed below. These volumes provide valuable references for Infantry squad training and evaluation.

Guide for the use of SIAF program descriptions
Composite Training Evaluation

<u>Program Descriptions</u>

1. Land navigation
2. Delivery of indirect and aerial fire support
3. Use of camouflage, cover, concealment, and stealth
4. Human maintenance
5. Fundamentals of tracking
6. Communications
7. Use of aerial photos
8. Physical conditioning and combatives
9. Use of individual weapons
10. Use of machineguns
11. Basic demolitions
12. Use of handgrenades
13. Use and detection of mines, booby traps, and warning devices
14. Combat first aid
15. Use of image intensification devices
16. Leadership
17. Intelligence
18. Mission, organization, and employment
19. Airmobile procedures
20. Stream-crossing expedients and small boats
21. Basic military mountaineering
22. Use of sensors
23. Patrolling
24. Survival, evasion and escape
25. Civic action, language development, and training of indigenous forces

Jones, F.E., & Odom, W.F. <u>Moonlight II: Training the Infantry soldier to fire the M1 rifle at night</u> (HumRRO Technical Report 15). Washington, D.C.: George Washington University, Human Resources Research Office (Human Research Unit No. 3, Ft. Benning, Georgia), December 1954.

Although the reported study involved a comparison of techniques used to train individual skills, the training principles used may also be applicable to team training. In training soldiers to fire the M1 rifle at night, one technique was found to be particularly effective. This technique was based on the assumptions that "the trainee learns best by

doing" and that "verbal instruction or explanation should never be used until the trainee has first provided himself, through his own performance and hence to his complete satisfaction, with firm experiential referents for the ideas that will be verbally presented" (p. 31) during formal instruction. In essence, it is necessary to "show the soldier what he cannot do, and why not; to show him how he can, and why; and to let him prove he can, for his own confidence and to clinch the training" (p. 16).

Application of these concepts to training soldiers to fire the M1 rifle at night resulted in the following program. Three hours of familiarization firing at night was given to show the soldier how hard it is to hit targets at night, followed by three hours of corrective firing by daylight to show and ingrain the proper corrections for night conditions, two hours of night vision instruction to explain how to pick up and not lose track of targets at night, and finally three hours of night firing to convince the soldier he can be effective at night by using the techniques he had learned.

Kraemer, R.E., & Kristiansen, D.M. A prototype crew drills training program for XM1 tank gunnery: Company commander's manual (ARI Research Product 79-17). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, Ft. Knox Field Unit, November 1979. (DTIC No. AD A078 899)

A series of fourteen crew drills was presented for XM1 tank gunnery. Crew drills are one means of bridging the gap between individual crew member training and tank platoon exercises. For each crew drill the following training information was presented: administrative requirements, tasks that must be performed by each of the crew members as well as tasks that must be performed by various subdivisions of the crew (called team task requirements), the training objective including the training conditions and training standards evaluation criteria, and a flow chart of crew members' actions. The flow chart indicated some crew coordination requirements not specified as team task requirements. Revisions to the document are expected. However, the report does indicate one approach to formally integrating individual and team requirements in a training program.

Kress, G. & McGuire, W.J. Implementation and evaluation of the tank crew training program for USAREUR units (ARI Research Note 79-40). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1979.

Two tank crew gunner training programs were examined. The conventional training program was based on a sequence of simple to more complex tasks, structured in accord with tactical scenarios. Individual training was given first, followed by crew exercises. The experimental program differed from the conventional program in that the training exercises were based on performance objectives, and the tactical scenarios provided for the evaluation of component skills as well as overall crew performance. One tank battalion participated in each

training program. In general, the experimental training program was as effective as the conventional training program. Although limited information was provided on each program, the report did indicate that the two programs reflected different approaches to tank crew training.

McGuire, W.J., & Kress, G. Tank platoon training program outline for USAREUR units (ARI Research Report 1229). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, February 1980.

A training program outline for preparing tank platoons to perform to standard in the Table IX tank platoon battle run was presented. The training guidelines included conditions for the exercises, performance requirements, performance standards, suggested training methods, study references, types of feedback that could be given, and resources necessary for the exercises. Many of the training tasks required either a high degree of teamwork by the tank crew or a high degree of coordination between the tank crews and the platoon leader.

Morgan, B.B., Coates, G.D., Alluisi, E.A., & Kirby, H.H. The team-training load as a parameter of effectiveness for collective training in units (ITR-78-14, prepared for U.S. Army Research Institute for the Behavioral and Social Sciences). Norfolk, Va.: Old Dominion University, May 1978. (DTIC No. AD A063 135)

See reference in Section C1. The authors made some recommendations regarding team turbulence and how to integrate untrained individuals into teams. "If fewer than 10 percent of a team/crew members are untrained, then the best strategy would be to assign untrained persons uniformly throughout so as to minimize the proportion of untrained personnel in any one team/crew. If the personnel turnover is greater than 80%, then the best strategy (and probably the most cost-effective) would be to assign maximum numbers of untrained members to certain teams and to schedule those teams for earlier team-training missions, even at the expense of postponing the training of teams/crews that have been maintained with fully trained personnel, some of whom have been transferred from teams/crews that are assigned high percentages of untrained individuals" (p. 21).

O'Brien, R.E., Crum, W.J., Healy, R.D., Harris, J.H., & Osborn, W.C. Trial implementations of the tank crewman skills training program (TCST) (ARI Technical Report 78-A29). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978. (DTIC No. AD A061 226).

See reference in Section F1. Several guidelines presented in the report regarding the training of tank crew skills apply to other team settings as well: (a) individual readiness training should be closely tied to crew training requirements, and (b) individual readiness training should progress rapidly to crew readiness training.

Schrenk, L.P., Daniels, R.W., & Alden, D.G. Study of long-term skill retention (NAVTRADEVCEN Technical Report 1822-1). St Paul, Minn.: Honeywell, April 1969. (DTIC No. AD 503 679)

See reference in Section F1. Skill retention of Navy anti-submarine rocket teams was examined. Recommendations regarding training were as follows:

a. Substantial individual operator training should be accomplished prior to team training.

b. Subteams need to understand how their performance interacts with other subteams and influences total team performance.

c. Team training should be given on a periodic basis in order to insure retention of team skills.

d. The entire team should participate in team training, including the appropriate officers who add leadership, stress, and motivation, and improve team cohesion.

e. Standardized training and evaluation materials should be used with team training devices.

Shriver, E.L., Griffin, G.R., Hannaman, D.L., & Jones, D.R. Small combat arms unit leader training techniques: Rules of play for two player/multiplayer Infantry mapboard games (ARI Research Product 79-4). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1979.

The report described a simulation procedure, called TOX (Tactical Exercise), for training Infantry leaders at the squad and platoon levels in tactical decision-making. Such tactical skills as anticipation of enemy actions, planning concerted actions against the enemy, placing personnel in locations most likely to give them an advantage over the enemy, planning for use of the most effective weapons in a given situation, command and control, and contingency planning as more information about enemy and friendly actions is received were stressed. The leader skills acquired through the board game play should be transferable to actual field exercises with troops.

Description of the two-sided, free-play map exercise included the gaming materials, rules for direct and indirect fire, rules for movement, controller guidelines, and after-action review guidelines. The game can be played with two players (i.e., squad leaders) and a controller, or four players (two squad leaders, two platoon leaders) and two controllers (indirect and direct fire).

Shriver, E.L., Henriksen, K.F., Jones, D.R., & Onoszko, P.W.J. <u>Development of a leader training model and system</u> (ARI Research Note 80-3). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1980.

See reference in Section B. The authors questioned the applicability of the instructional system development (ISD) model to many combat arms training situations, particularly tactical operations where dynamic free-play exercises are common. The proposed training model identified three types of learning processes: experiential, analytic, and procedural. Experiential and analytical learning settings were predicted to provide the best learning environment for developing leader skills in management, communication, problem-solving, and tactics, while procedural training was deemed most appropriate for the development of technical skills. The authors felt that experiential learning such as engagement simulation should be conducted early since analytic and procedural learning may be more effective after a need for such learning has been demonstrated in a simulated context.

F. DESCRIPTION OF TEAM MEMBER INTERACTION AND TEAMS TASKS: METHODOLOGY

Procedures and instruments used to describe team/small group processes as well as conceptual developments regarding the nature of group are cited in this section. Measures of team member interactions that stress the performance, rather than the social, dimensions of group/team interactions are emphasized. Ways of measuring, describing, and conceptualizing team tasks are also presented. Military studies are starred in the classification list below.

1. Interaction (Performance Dimensions)

Altman (1966a)
Billings et al. (1978)
Boldovici (1979)*
Briggs & Johnston (1966b)
Brown (1967)*
Buehler & Richmond (1963)
Connelly, Comeau & Steinheiser (1980)*
Dieterly (1978)*
George (1977)*
Glaser, Glanzer & Morten (1955)*
Glanzer & Glaser (1955)*
Glanzer & Glaser (1959)
Henriksen et al. (1980)*
Hood et al. (1960)*
Knerr, Nadler & Berger (1980)*
McRae (1964)
Meliza, Scott & Epstein (1979)*
Miller (1958)
Nieva, Fleishman & Rieck (1978)
Obermayer et al. (1974)*
Obermayer & Vreuls (1974)*
O'Brien (1968)
Roby (1957)
Siegel & Federman (1973)*
Williges, Johnston & Briggs (1966)*
USARIEM Studies on Field Artillery FDC (1978-1980)

2. Interaction (Social Dimensions)

Clark (1969a)*
Henriksen et al. (1980)*
Jacobs (1963)*

3. Tasks/Task Structure

Altman (1966b)
Connelly, Comeau & Steinheiser (1980)*
Daniels et al. (1972)
Dieterly (1978)*
Dyer (1980)*
Fleishman (1975)
George (1977)*
Glaser, Glanzer & Morton (1955)*
Hackman (1969)
Hammell & Mara (1970)*
Helm (1976)*
Lord (1976)
O'Brien (1967)
Roby & Lanzetta (1958)
Root et al. (1979)*
Scott et al. (1979)*
Shaw (1963)
Sorenson (1971)
Thibaut & Kelley (1959)
Warnick et al. (1974)*
Wheaton (1968)

Altman, I. Aspects of the criterion problem in small group research. I. Behavioral domains to be studied. Acta Psychologica, 1966, 25, 101-131. (a) (DTIC No. AD 633 248)

Altman critiqued past efforts at measuring group performance. Dependent measures have been too restricted, focusing on task-relevant behaviors alone and ignoring social-emotional-interpersonal behaviors. Little examination of the sequence of task-relevant behaviors that precede final performance output has been made. Procedures have ignored the dimension of time, providing no indication of changes in group process with time.

Altman discussed the characteristics of and differences between various behavioral observation systems: form rather than the substance of behavior is usually observed, only some systems provide records of sequence of behavior, and the level of category abstraction varies from system to system. Altman argued that systems should be developed that encompass a broader range of behaviors, reproduce more group activity, and allow for the systematic linkage of various behaviors.

A new multi-dimensional observation system was proposed. However, no data were presented on the use of the system. The major functional dimensions of the system were as follows: initiator of the interaction or the actor (person, subgroup or group), form of the interaction (ask, inform, infer, repeat, evaluate, tell or order, act or operate), focus or objective of the interaction (person, subgroup, group, equipment), and immediate recipient or referent (person, subgroup, group, equipment). Such a procedure could record the form of such interactions as: "John asked Mary for more information than she possessed about the problem." Second and third-order dimensions were presented as well. Altman stated that such a system would provide for analysis of individual roles and group structural dynamics (people as structurers, criticizers, information providers), examination of interrelationships among behaviors, description of developmental changes in a group as it progresses toward a goal, and measures of independent variable effects.

Altman, I. Aspects of the criterion problem in small group research. II. The analysis of group tasks. Acta Psychologica, 1966, 25, 199-221. (b)

The problem posed by Altman was as follows: "It is not enough to merely say that a given X-Y relationship holds for task A, but not for task B. We need to know the essential properties of the two tasks so as to be able to link the behavioral differences to the task characteristics. In short, we need to develop an understanding of the fundamental parameters in terms of which tasks can be described so as to be able to more systematically map between tasks and between behavior and task characteristics" (p. 200). Altman reviewed several approaches to task description. Roby and Lanzetta's analysis of critical task properties was viewed as a major attempt to link task properties to behavioral requirements.

Most of the article focused on the need to establish a hierarchical description of tasks. At the lowest level, behavioral acts are specified, e.g., persons 1 and 2 must mutually exchange information on a continuous basis. At the next level, broader behavioral requirements are specified, e.g., processing, cooperation, attending, orientation. Finally, intrinsic task properties are described, e.g., stimulus input rate, equality of information distribution. The multi-dimensional space defined by Altman in the first article in this series was then applied to the task description problem. Although the approach does not provide adequate mapping between the different levels of description and does not handle such task characteristics as difficulty and complexity, it does allow comparison of tasks and can be used to describe a large variety of tasks.

Billings, A.G., McDowell, S.W., Gomberg, C.A., Kessler, M. & Weiner, S. The validity of time-sampling in group interactions. Journal of Social Psychology, 1978, 104, 223-230.

The validity of time-sampling procedures as a function of time-length of sampling unit, individual vs. group behavior vs. behavioral category, and size of observational category was examined. Measures of group behavior required more samples than measures of individual behavior. Small, specific observational categories required more samples than more general categories. In the particular context examined (six-person discussion groups), two-minute sampling periods, as opposed to six and ten-minute periods were the most efficient size. Six-minute sampling units were more efficient than ten-minute sampling units.

Boldovici, J.A. Analyzing tank gunnery engagements for simulator-based process measurement (ARI Research Report 1227). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1979.

The report presents data on tank gunnery tasks that are required for the development of simulators to represent tank crew actions during the target engagement process. Process measurements should help to diagnose crew problems and improve overall crew performance. For each gunnery task and each crew member position, the stimuli and overt responses comprising that task were identified, responses and enabling skills for those responses were determined, and measurement specifications for responses and enabling skills were provided.

Analytic methods presented focused on each crew member (tank commander, gunner, driver, loader). Flow decision-response diagrams indicated that most crew interactions were verbal and were between two individuals (mainly the tank commander with either the gunner, loader, or driver). Measurement procedures focused on the speed and accuracy of individual crew member's actions.

Briggs, G.E., & Johnston, W.A. Laboratory research on team training (NAVTRADEVCEN 1327-3). Columbus, Ohio: Ohio State University, May 1966. (b) (DTIC No. AD 485 636).

See reference in Section E1, Ohio State University CIC studies. One experiment examined the roles of verbal and visual communication channels in a CIC environment (radar controllers). Results showed that addition of the verbal to the visual channel did not improve performance beyond that achieved with the visual channel alone. Content analyses of the verbal communication indicated, however, that tactical messages did facilitate performance although controllers used these at a low rate. The authors recommended that verbal channels under such conditions be restricted to the transmission of essential and simple information, and that training in efficient verbal coding of such information might improve task performance.

Brown, R.L. A content analysis of communications within Army small-unit patrolling operations (HumRRO Technical Report 67-7). Alexandria, Va.: George Washington University, Human Resources Research Office, Division No.4, Fort Benning, Georgia, June 1967.

A content analysis was made of messages sent during Ranger patrols at both jungle and mountain training sites. Observers used portable tape recorders to record transmission time and mode, the content of each message, and the designation of sender and receiver.

Two major content areas were established: commands and information. Within each content area, six subareas were identified: movement, security, fire, intelligence (command content only) or identification (information content only), command and control, and equipment considerations. Content analyses were made on five phases of the patrol: I, departure of friendly lines to occupation of objective rallying point; II, occupation of rallying point to initiation of the assault; III, the assault; IV, end of assault to departure of objective rallying point; and V, departure of rallying point to reentry of friendly lines.

Both messages and transmissions were recorded. A message referred to what was said; a transmission, to the act of saying something. Thus a given message could be (and was) repeated many times. There were approximately twice as many command messages/transmissions as there were information messages/transmissions. Voice was the most frequent mode of communication, followed by message-by-file, radio, and arm and hand signals. Most of the transmissions (62%) occurred during Phase I, while during the assault and immediately after it communication "came to a virtual standstill" (7% of all transmissions occurred here, mainly commands).

The patrol leader was the most frequent communicator followed by the assistant patrol leader. Most of the command messages were directed towards the patrol as a whole, rather than to individual patrol members. The patrol leader, assistant leader, and point served as a nucleus for

the other messages. As might be expected, the patrol leader received very few command messages.

Most of the command messages were movement commands. The other major command message category was that of command and control --- personnel measures (e.g., either locating, assigning duties to, or positioning patrol members). Information messages usually focused on personnel status reports or identification of terrain/personnel.

Buehler, R.E. & Richmond, J.F. Interpersonal communication behavior analysis: A research method. Journal of Communication, 1963, 13, 146-155.

Buehler and Richmond argued that communication should not be restricted to speech and/or speech symbols, but should include all transactional behavior ranging from biochemical transactions to transactions involving the use of technological devices for storing and transmitting information. An observation scheme was developed which included the following major communication categories and subcategories (p. 150-151):

1. Biochemical

   a. Body contact: Any body contact, with any part of the body.

   b. Affect: Reactions which do not require body contact such as laughing, crying, blushing, sighing, etc.

2. Motor Movement

   a. Posture: Any stance or posture shift during the interpersonal situation involving the whole body or major parts.

   b. Facial Movement: Any muscular movement involving face or head, such as smile, frown, winking, nodding, shaking head.

   c. Gesture: Any use of body extremeties such as waving arm, pointing with arm, hand, or fingers, shrugging shoulders, using body movements to demonstrate or illustrate.

3. Speech

   a. Sound: Oral utterance without verbal form

   b. Sound: Oral utterance in verbal form

4. Technology: Use of any instrument defined in the immediate culture as a communication tool.

The observation record was devised for recording observable behavior in ten-second time intervals on more than one person. More than one form of communication could be recorded within each observation interval.

Clark, R.A. Analyzing the group structures of rifle squads in combat. In Collected papers prepared under work unit INTERSQUAD: A study of the factors which account for the differences between effective and ineffective rifle squads. (HumRRO Professional Paper 8-69). Washington, D.C.: George Washington University, Human Resources Research Office, March 1969, pp. 16-24. (a) (DTIC No. AD 686 621)

Clark applied sociographic analytic techniques to Infantry rifle platoons, and described how to construct a sociographic matrix. Formulas for indices of integration, cohesion, cliquishness, squad independence, and sociographic status were presented.

Connelly, E.M., Comeau, R.F. & Steinheiser, F. Team performance measures for computerized systems Final Technical Report, Contract #MDA-903-79-C-0274, Conducted for Army Research Institute for the Behavorial and Social Sciences). Vienna, Va.: Performance Measurement Associates, November 1980.

A procedure was described for portraying the performance of computerized tactical data processing systems, specifically the TACFIRE system used by Fire Direction Center teams (three-man teams) within Field Artillery Battalions. In the introduction of the report, the need for better team performance measures was stressed, particularly the need to assess team "interaction." Two criteria for team performance measures were cited: measurement comprehensiveness which reflects the ability of the measure to respond to each factor that affects the mission performance of the system, and measurement sensitivity which reflects the degree to which the measure reveals the effect on mission performance of changes in the performance of individual tasks or types of tasks. Another fundamental principle that must be considered in performance measurement is that the performance of a specific task can have a unique effect on total mission performance (e.g., its effect can vary with the stage of mission completion).

The approach used can be summarized as follows. A mission is divided into its component states (points in a mission when alternative task sequences can arise; a state must exist for some period of time and have a recognizable end point; two or more states cannot exist simultaneously). Once the states have been identified, the tasks required to complete a state are identified and the times for each task determined. The transition times between states can then be determined. In addition, the probabilities with which each state follows every other state are determined. From all this information it is then possible to determine the time required to complete the entire mission. In addition to these procedures, reference-task performance is defined, that is, an established way of performing a particular task, which may include time required to complete the task, the number of errors permitted in attempting the task, the times required for particular levels of training and expertise, etc. Comparison of reference-task performance with computed performance can then be made.

The approach was applied to a specific TACFIRE mission, and the report included the data collection procedures and model results. The authors also proposed five types of generic tasks: manual, cognitive, interactive, communication, and external. Only the first three were extensively involved in the particular TACFIRE mission examined.

A limitation of the present approach is its use of time to represent interactive tasks. The authors stated that both the quality and time of interactions must be portrayed, since both factors may affect the sequence and nature of subsequent actions taken by a team.

Daniels, R.W., Alden, D.G., Kanarick, A.F., Gray, T.H. & Feuge, R.L. Automated operator instruction in team tactics (NAVTRADEVCEN 70-C-0310-1). St. Paul, Minn.: Honeywell, January 1972. (NTIS No. AD 736 970)

See reference in Section A. A procedure for analyzing team tasks was developed and applied to Navy teams. The task taxonomy divided the task into stimulus, cognition and response elements.

Dieterly, D.L. Team performance: A model for research. In E.J. Baise & J.M. Miller (Eds.), Proceedings of the Human Factors Society. 22nd annual meeting. Santa Monica, Calif.: Human Factors Society, 1978.

See reference in Section B. Dieterly proposed several ways of examining task dependencies within a team called task interdependence and task interdependency. A task is dependent if its completion depends upon the completion of another task by another team member. Task interdependency was defined was the ratio of the total number of tasks required to accomplish an objective within a reasonable period of time to the maximum number of tasks a single member can handle.

Dyer, J.L. The initial training of individual and team skills: An exploratory investigation of Engineer bridge specialists (ARI Working Paper, FBNG FU 80-1). Fort Benning, Ga.: U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Benning Field Unit, October 1980.

See reference in Section E1. The following distinction was made between individual and team skills. Individual skills referred to activities that could be or were performed independently of other team/group members. Team skills referred to activities that had to be performed in response to the actions of other team members or that directed the actions of other team members.

Fleishman, A. Toward a taxonomy of human performance. American Psychologist, 1975, 30, 1127-1149.

Fleishman cited the need to develop a system for classifying tasks that would lead to predictions regarding how such factors affect human performance. He reviewed four approaches to such classifications:

behavior description, behavior requirements, ability requirements, and task characteristics. Examples of the ability requirements and task characteristics approaches were given, followed by a brief review of studies that have attempted to link the two approaches in order to better describe the types of abilities required for different types of tasks. The ability requirements approach usually depends on factor analytic methodology to identify relatively enduring attributes of human performance. The task characteristics approach attempts to identify intrinsic, objective properties of tasks based upon task component analysis and rating scale procedures.

George, C.E. Testing for coordination in small units. Proceedings of the Military Testing Conference, 1977, 19, 487-497.

George distinguished between crews and teams and between the forms of response coordination in each. Small military units can be distinguished by the degree of group structure and the flexibility of that structure. Group structure was defined as the ratio of the number of role specialities to the number of group members. If each unit member has a unique speciality, then that group is completely structured; if every member has exactly the same role speciality (no leadership) then the group is completely unstructured. Flexibility of structure can be estimated by the probability of role interchange in the operational environment. For example, the rifleman within an Infantry squad has a very high probability of being required to take over some of the roles of a grenadier or team leader during operations. George labeled highly but flexibly structured small units as teams (e.g., Infantry squads), and highly but less flexibly structured units as crews (e.g., aircraft and tank crews).

George argued that it is possible to measure coordination in small military units, and cited several studies of Infantry squads where observers were able to tally coordinative responses (e.g., redistributing ammunition as required, covering a large sector of fire when another member could not cover his sector). Verbal coordination within crews is often difficult to measure since efficient crews often operate with a minimum of verbal behavior. However, there is some evidence that sufficiently difficult tasks may force crew members to communicate verbally when, and only when, the task demands such coordinating responses.

Glaser, R., Glanzer, M. & Morten, A.W. A study of some dimensions of team performance (AIR Technical Report, Office of Naval Research Contract N7onr-37008, NR-154-079). Pittsburgh, Pa.: American Institute for Research, September 1955. (DTIC No. AD 078 433)

The purpose of the study was to develop variables that described the communication structure among team members and to compare existing teams on these variables. Communication was defined broadly as all interaction between team members (e.g., verbal command, hand signal, a checked-out piece of equipment) necessary for accomplishing a task. The social behavior of teams was not examined.

Fourteen variables were developed to describe the nature and extent of communication links among members of a team.

Link frequency: indicates the complexity of the team's communication structure

Communication frequency: measures the general activeness of a team

Concurrent activity: reflects the extent to which members of a team act simultaneously

Process differentiation: indicates the extent to which a team operation is differentiated into six different classes of activities (observing, relaying, manipulating, computing, deciding or supervising)

Input magnitude: reflects the complexity of inputs handled by team members

Sequence predictability: the degree to which the course of team activity can be predicted. Predictability is decreased by decisions made by team members and inputs received from sources outside the team.

Intra-team dependence: reflects the extent to which a team generates the inputs which go to its members. To the extent that a team is self-contained, more control of its operation is possible.

Communication media: describes the different means of communication that a team employs

Communication significance: reflects the extent to which certain team members are central points for receiving and transmitting messages.

Supervisory ratio: reflects extent to which a team includes members who function primarily in a supervisory capacity

Output irrevocability: extent to which team outputs have little possibility of being changed

Anticipatory cuing: extent to which cues are available that "warn" team members that their turn to act will occur at some subsequent time.

Urgency: speed and pressure requirements under which team operation occurs

Saturation: extent to which a team is likely to receive inputs at a greater rate than it can handle adequately

Six Navy teams on the USS Midway were observed and interviewed in order to construct a structural and sequential description of the communication among team members when performing a specific task. These descriptions were used to compute values on the first ten of the fourteen descriptive variables just cited. The six teams were then compared on each of the variables, and suggestions for further refinement and study of the variables were made.

Glanzer, M. & Glaser, R. A review of team training problems (Prepared for Office of Naval Research). Pittsburgh, Pa.: American Institute for Research, September 1955. (DTIC No. AD 078 434)

Although the review was written in 1955, many of the team research problems identified by Glanzer and Glaser still exist today, and many of the methodological approaches they used to study Navy teams could be applied to other types of teams. Three deficiencies in Naval team training were identified: lack of clearly stated principles for team

training procedures, lack of clearly stated criteria for good teams, and lack of adequate measuring devices for team behavior.

One of the major purposes of the study was to describe the activities of five Navy teams. In order to obtain such descriptions, decisions had to be made in each of the following areas: definition of team, selection of situations in which to examine team activity (typical as well as infrequent situations), definition of team activity (by time units or by acts), length of the mission used to describe the team, and weights assigned to cyclical and peak activity periods. Glanzer and Glaser recorded the sequence of team activity and coded acts by each team member according to input, process and output. In addition, each act was classified for content: observation, relay of information, manipulation, decision, computing, and/or supervising. Glanzer and Glaser stated that such team descriptions can be used to relate team characteristics to errors (e.g., is the amount of simultaneous activity related to probability of errors?), to analyze activity content (relationship of content to training and operational problems), and to identify structural characteristics of teams and their relationship to team performance.

Valuable information regarding team performance was obtained by interviewing instructors in order to determine characteristics of effective and ineffective teams. Other information obtained from interviews included: errors made by team members, how and when errors were corrected, and the extent to which cross-training of team members was needed. The scarcity of team performance measures was noted. Two techniques cited for improving assessment and analysis of teams were the overloading method and the subtraction method. General factors that should be considered in team training (fidelity of simulation, feedback and training criteria) and in the construction of teams (number of men, distribution of special skills, supervisory structure) were discussed briefly.

Glanzer, M. & Glaser, R. Techniques for the study of team structure and behavior. Part I: Analysis of structure. Psychological Bulletin, 1959, 56, 317-322. (DTIC No. AD 135 412)

The authors reviewed mathematical techniques for summarizing and describing the interactions or communications within a group. Although many of the techniques presented were originally developed for describing patterns of personal likes and dislikes for other group members, some of the techniques can also be applied to describing communication patterns between group members. When the report was published, some of the mathematical techniques were limited to handling binary data, and therefore could not handle multiple communications between group members.

Communications or links between group members were summarized in matrix form, e.g., rows representing the sender, columns representing the receiver, and cell entries representing whether or not a relationship existed between a particular sender and a particular

receiver. Many of the mathematical indices were based upon matrix algebra computations. Some of the more promising techniques for team research are cited briefly below.

An index of concentration was described which reflects the extent to which messages are received by a small number of individuals or sent by small number of individuals. A status index was described that can be used to indicate the amount of material that comes to an individual both directly and indirectly and an individual's importance, both directly and indirectly, as an information source.

Some techniques for comparing groups of the same size have been developed. Such techniques would allow comparison of teams of the same type that are composed of different personnel, an examination of change of team interactions over time, and/or estimation of the discrepancy of group communication from an ideal or required pattern.

Mathematical techniques, including factor analysis, to identify subgroups were discussed as well as the use of graph theory to determine the role of key or liaison positions within a group (i.e., positions that serve as links between subgroups).

Hackman, J. R. Toward understanding the role of tasks in behavioral research. Acta Psychologica, 1969, 31, 97-128.

Hackman reviewed various attempts at defining and describing tasks, and then proposed a general approach for analyzing the effects of tasks that should be considered in designing research studies and in determining the situations to which the study results are generalizable. No distinction was made between individual and group tasks, although the focus was on individual tasks.

Researchers have used one of four approaches in describing tasks: (a) task qua task approach, (b) task as a behavior requirement, (c) task as behavior description, and (d) task as an ability requirement. Hackman concluded that the task qua task approach has the advantages of operational specification and is a task property which can be measured independently of the behavior to which it is expected to be related. However, such description may not always be possible because of the large number of descriptive dimensions that can be applied. Both the task as behavior description and task as ability requirement approaches have limits in that researchers need some other means of describing and classifying independent variables other than in terms of the characteristics of the subject (often the dependent variables in the study) to which they wish to predict. The behavior requirements approach refers to specifying those behaviors that must be emitted by an individual for adequate performance. Since they will differ from task to task and will depend only on what the task demands, such requirements are viewed as characteristics of the task, rather than as characteristics of the subject.

A general definition of task was proposed, based upon that of Gagne' (p. 113):

> A task may be assigned to a person (or group) by an external agent or may be self-generated. It consists of a stimulus complex and a set of instructions which specify what is to be done vis a vis the stimuli. The instructions indicate what operations are to be performed by the subject(s) with respect to the stimuli and/or what goal is to be achieved.

Hackman stressed three aspects of this definition: stimuli, instructions about operations, and instruction about goals. Various systems that have been proposed to describe each of these aspects were cited. Some dimensions that have been used in much behavioral research apply to more than one aspect of the task. For example, the stimuli may be ambiguous and/or the operational instructions may be ambiguous.

A general model of analyzing the effects of tasks was then proposed. The objective task input must be specified (i.e., stimulus materials, instructions); the way in which the subject redefines (perceives) this input must be considered; the subject forms hypotheses regarding how to deal with the task; the individual performs the task acquiring what Hackman calls process-outcome links regarding what outcomes result from

what processes; some type of feedback regarding the outcome is obtained; and the individual may then perform the task again.

Hammell, T.J., & Mara, T.D. Application of decision making and team training research to operational training: A translative technique. Final Report (TR NAVTRADEVCEN 68-C-0242-1). Orlando, Fla.: Naval Training Device Center, April 1970. (DTIC No. AD 871 024).

The report focused on the problem of applying training research findings from laboratory-like settings to operational training situations of Navy teams that emphasize decision making behavior (e.g., antisubmarine warfare and antiaircraft warfare tactical operations). A review of the decision making literature yielded few studies on the training of decision making. Decision skills were distinguished from decision tasks within the literature, with the former being more inclusive than the latter (i.e., different decision tasks may reflect the same decision skill). Several decision skill taxonomies were found in the literature review. The one developed by Sidorsky, Houseman and Ferguson (1964) was used by the authors since they judged it to be the most comprehensive and applicable to both operational training and laboratory situations. This taxonomy is summarized below (entitled the ACADIA Taxonomy of decision skills, p. 15).

Acceptance	Establish characteristics of enemy tactical unit (or external entity)
Change	Increase relative advantage (informational of functional) of own tactical unit vis-a-vis enemy tactical unit
Anticipation	Establish future status (state or intention) of enemy tactical unit relative to own tactical unit
Designation	Maximize congruence between own tactical unit capabilities and emergent situational requirements
Implementation	Resolve the tactical situation
Adaptation	Preserve own tactical unit in face of unexpected circumstances

A procedure relating observed laboratory performance to real-world performance was developed by focusing on decision-making errors (called behavioral deficiencies by the authors). The procedure used deficiencies rather than "appropriate" decision tasks since deficiencies were judged to be easier to observe. Five categories of deficiencies related to decision making were identified (p. 19).

Stereotypy	Overgeneralization of a particular response in a number of situations to the point that it becomes predictable to an enemy
Perseveration	Tendency to persist with a source of action after it is reasonable to make a new response or interpretation
Incompleteness	The degree to which the decision maker avails himself of all relevant information in the tactical situation
Untimeliness	Tendency to make a premature move or delay too long, i.e., not use an appropriate amount of time
Series Inconsistency	Performance of consistent responses based on poor logic rather than overgeneralization in a series of sequentially dependent or interrelated actions

Results from the training studies on decision making were then categorized in terms of both the decision skill taxonomy and the behavioral deficiency categories. These associations were then predicted to occur in Navy training settings. Observations in a submarine trainer and a real-world submarine exercise were made to determine the relationship between the training study predictions and actual team decision making behavior. The authors concluded that sufficient overlap occurred between the predictions and actual observations to warrant further development and application of the technique to tactical situations and problems.

Helm, W.R. Function description inventory as a human factors test and evaluation tool: An empirical validation study (Fourth interim report). Patuxent River, Md.: Naval Air Test Center, July 30, 1976. (DTIC No. AD B013 189)

A Function Description Inventory (FDI) was developed to analyze the operational functions of aircraft crewmembers and to supplement the traditional human factors engineering field testing on an S-3A airplane. Operational functions of each crewmember were defined by a hierarchy of roles, duties, and tasks, with roles being the broadest category of activity and tasks being the smallest category (e.g., Role-system manager; Duty-assess aircraft system; Task 1 - assess aircraft system readiness for flight prior to takeoff; Task 2 - monitor system for proper in-flight operations). Each role, duty, and task was then rated on four dimensions: importance for mission success, frequency of performance, adequacy of training, and effectiveness of the system itself. Scale values used for each dimension were provided in the report. Operator judgements of the functions were validated with information from field testing of the aircraft.

Henriksen, K.F., Jones, D.R., Hannaman, D.L., Wylie, P.B., Shriver, W.L., Hamill, B.W., & Sulzen, R.H. Identification of combat unit leader skills and leader-group interaction processes (ARI Technical Report 440). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1980.

See reference in Section B. Many of the leader skills cited by the authors as crucial in combat situations and engagement simulation studies refer to various forms of interactions between the leader and his subordinates.

Jacobs, T.O. Leadership in small military units (HumRRO Professional Paper 42-68). Washington, D.C.: George Washington University, Human Resources Research Office, December 1968. (DTIC No. AD 682 340)

See reference in Section C1. Procedures were developed to measure "teamwork" or coordination activities performed by the Infantry squad/platoon leader: defining behaviors, pre-task motivation, post-task motivation, handling disruptive influences, getting information, and NCO use and support.

Hood, P.D., and others. Conference on integrated aircrew training (WADD Technical Report 60-320). Wright-Patterson Air Force Base, Ohio: Air Research and Development Command, Wright Air Development Division, July 1960. (DTIC No. AD 240 638)

See reference in Section A. Several research projects on aircrew training were discussed, with emphasis upon the nature of crew interaction. Krumm distinguished two types of crew coordination: mechanical coordination where individuals must synchronize their actions according to standard operating procedures, and response improvisation, where crew members must interact to solve problems for which a stock answer is not available. Instruments developed to measure crew behavior and knowledge were cited. Distinctions between the actions of experienced and inexperienced crews were made.

Knerr, C.M., Nadler, L.B., & Berger, L.E. Toward a Naval team taxonomy (Interim Report, ONR Contract No. N00014-80-C-0087). Arlington, Va.: Mellonics Systems Development Division, December 1980.

See reference in Section A. One part of the taxonomy developed for Navy teams included communication patterns within a team and the nature of the network established to accomplish team tasks.

Lord, R.G. Group performance as a function of leadership behavior and task structure: Toward an explanatory theory. Organizational Behavior and Human Performance, 1976, 17, 76-96.

See reference in Section C1. The relationship between task structure and leadership behavior was examined. Task structure was varied according to Shaw's dimensions of decision verifiability, goal

clarity, goal path multiplicity, and solution multiplicity. It was hypothesized that task structure and leadership behavior would be inversely related since they both have similar effects upon task performance, and that the relationship between performance and leadership orientation would be inversely related to task structure (i.e., for tasks with high structure the relationship would be low, for tasks with little structure the relationship would be high). Results supported the first hypothesis but not the second.

McRae, A.V. Interaction content and team effectiveness (HumRRO Technical Report 66-10). Alexandria, Va.: Human Resources Research Office of the George Washington University, HumRRO Division No. 4, June 1964. (DTIC No. AD 637 311)

See reference in Section D. Verbal interactions among four-man problem solving groups were coded into three basic categories: organizational interactions, task-specific interactions and residual interactions. Task specific interactions correlated positively with time to solve problems and correlated negatively with errors when time was partialed out of the relationship.

Meliza, L.L., Scott, T.D., & Epstein, K.I. REALTRAIN validation of rifle squads II: Tactical performance (ARI Research Report 1203). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, March 1979.

See reference in Section E1. As part of the REALTRAIN validation studies on rifle squads, tactical performance of the squads was observed. Comparison of REALTRAIN squads with conventionally trained squads indicated tactical differences, and some of these tactical differences reflected differences in team coordination and planning. Such process measures correlated with mission success.

Miller, F.B. "Situational" interactions --- A worthwhile concept? Human Organization, 1958, 17, 37-47.

Miller argued that three types of interactions should be distinguished within work teams: originations, where an individual clearly is the originator of an activity by another individual through verbal or nonverbal communication; responses, interactions in which a person clearly responds to a teammate through verbal or nonverbal means; and situational interactions, which refer to interpersonal contacts that are determined by the regular flow of work and are so routinized that no verbal or gestural communication takes place (i.e., the situation dictates the timing and nature of some interpersonal contacts, rather than either of the parties originating for the other). Miller cited an essay by Burling on surgical teams where such situational interactions were stressed: "This is the highest and most efficient type of cooperation known. It is possible only where every member of the team knows not only his own job thoroughly, but enough about the total job and that of each of the members to see the relationship of what he does to everything else that goes on" (p. 39).

Miller documented the importance of distinguishing among originations, responses, and situational interactions from observations of glass working teams. Results showed, for example, that only the amount of originations correlated with work member status, and that the distribution of interactions among originations, responses and situational interactions varied as the product being produced required a change in the work flow. Miller also discussed the role of situational interactions in relieving supervisors from constant supervision of subordinates.

Note. - Situational interactions are also quite characteristic of military teams, and Miller's three categories should be considered when observing such teams.

Nieva, V.F., Fleishman, E.A., & Rieck, A. Team dimensions: Their identity, their measurement and their relationships. Washington, D.C.: Advanced Research Resources Organization, November 1978.

See reference in Section A. The team dimensions identified in the report specify some major ways in which team members interact and depend upon each other in carrying out team tasks (e.g., activity pacing, response coordination, load balancing). The report was a conceptual effort, rather than an attempt to quantify team dimensions.

Obermayer, R.W., Vreuls, D., Muckler, F.A., Conway, E.J., & Fitzgerald, J.A. Combat-ready crew performance measurement system: Final report (AFHRL-TR-74-108 (I)). Brooks Air Force Base, Tex.: Air Force Systems Command, December 1974. (DTIC No. AD B005 517)

Obermayer, R.W., & Vreuls, D. Combat-ready crew performance measurement system: Phase IIIA, Crew performance measurement. (AFHRL-TR-74-108(IV)). Brooks Air Force Base, Tex.: Air Force Systems Command, December 1974. (DTIC No. AD B005 520).

A system/facility for measuring combat aircrew performance was described. Of particular interest for team research were the six communication categories that were deemed important to measure in such a system. Timing of messages --- new crewmembers often fail to recognize what is important and therefore will jam more important messages, provide information at the wrong time, delay in providing information, or not provide information at a rate that permits effective response by other members. Accuracy of the message is critical in flight performance. Brevity of the message --- in combat situations radio and interphone traffic have been found to far exceed channel capacity; a standard vocabulary was proposed to reduce this problem. The number and frequency of communications --- one study found that experienced crews communicated less than inexperienced crews during routine operations, but communicated more frequently during weapons delivery. Instructors have found that new trainees communicate little until they become knowledgeable. Information content --- as communication skills improve one might expect that the information transmitted per unit of time would

increase. Performance changes --- there should be some measure of whether a communication had its intended effect.

O'Brien, G. *Methods of analyzing group tasks* (Technical Report No. 46). Urbana, Ill.: Department of Psychology, Group Effectiveness Research Laboratory, January 1967. (DTIC No. AD 647 762)

Distinctions among group tasks were based on a theoretical rather than an empirical perspective. Three forms of task analyses were identified from the literature: task-task (task considered as a system with component parts and relations), task-organization (tasks described by relating the task system to the organizational structure), and task-person (tasks described by relating the characteristics, responsibilities, and abilities of group members to specific task characteristics). The primary framework for classifying tasks was structural role theory. Digraph theory and matrix algebra were applied to task definition and used to generate indices of task dimensions such as inter-position co-ordination and goal path multiplicity.

O'Brien, G. The measurement of cooperation. *Organizational Behavior and Human Performance*, 1968, *3*, 427-439.

O'Brien distinguished between two forms of cooperation --- collaboration and coordination. Collaboration was generally defined as the extent to which different positions are allocated the same subtasks, while coordination was defined as the extent to which subtasks allocated to different positions need to be sequenced by definite precedence relationships. Numerical indices of coordination and collaboration were presented, based on structural role theory. Indices for both variables range from 0 to 1.0. The formulas were based on matrix operations which summarized the sequences among the subtasks and allocation of subtasks to positions within the group.

Some questions that remain unanswered are the mathematical dependency between the two indices, how to define subtasks in different contexts so that different group structures can be compared, and how to treat mathematically the problem of task repetition. If these questions could be (or have been) answered, the indices could provide useful tools in the comparison measurement of military teams.

Roby, T.B. On the measurement and description of groups. *Behavioral Science*, 1957, *2*, 119-127.

Roby discussed three levels of description that can be applied to groups: response aggregates (the raw data, the sequence of group member behavior), behavior indices (summary statistics of the behavior sequences), and endogenes (inferred properties of groups which account for behavior patterns; are invariant over sampling conditions). Discussion of each of these levels was rather general. A basic assumption was that the levels were ordered in terms of increasing stability and increasing difficulty of measurement.

The most specific discussion pertained to the response aggregate level. Such data should be indexed by the time or occasion of occurrence, the substantive or functional nature of the behavior, and the persons directly concerned. The time index could reflect a chronological scale, be related to a set of external events such as stimulus input, or reflect the order of events without reference to chronological time. When the article was written, no generally accepted procedures for classifying types of behavior existed. Three major referents were described: measures directed at specific individuals, measures directed at individuals or groups that are unidentified, and measures reflecting all group members such as product output.

Roby, T.B., & Lanzetta, J.T. Considerations in the analysis of group tasks. Psychological Bulletin, 1958, 55(2), 88-101.

The authors referred to the general neglect of task parameters in small group research and to the fact that hypotheses concerning relationships in small-group behavior cannot be generalized on the strength of haphazardly selected tasks. The paper presented a paradigm for isolating and defining important group task characteristics at a relatively molecular level. In addition, the importance of identifying task properties at a higher level of abstraction that serve as intervening variables between molecular task properties and task performance measures was stressed.

The descriptive paradigm involved a four-stage cycle of task events. The first set of events referred to task input variables --- some set of events that occurs in the group's environment such as variations in input displays and stress-inducing stimuli. The second set of events was called group input activities --- activities within the group that usually focus upon the process of collecting and disseminating information. The third stage of events referred to group output activities --- activities within the group made in response to relevant stimuli, activities such as decisions, commands, and motor and verbal responses. The last set of events referred to task output variables --- all environmental conditions that are in any way affected or modified by group activities (these events usually form the basis for evaluation of group performance). Each of these classes was then described according to three properties: descriptive aspects, which focus on the qualitative nature of the events as well as their frequency and possible measurement; the distribution of events in physical space or with respect to other events; and the functional behavior of events in terms of their occurrence over time or as a result of preceding events. Breakdown of group activity by the four event classes and the three types of event properties was assumed to provide a "molecular task description", i.e., a comprehensive and detailed description of any task.

However, a molecular description provides little basis for conveying the meaning of tasks in psychological terms or for comparing tasks. Roby and Lanzetta introduced the concept of "critical demands" to bridge the gap between molecular task properties and social psychological

variables. Critical demands were defined as distinctive features of particular tasks that require group behaviors for adequate task performance. At this early stage of conceptualization, no procedures were provided for identifying critical demands or for relating them to molecular properties. Examples of critical demands were orientation (determining the condition of variables in the task environment), mapping (the process by which a group anticipates or learns the consequences of various action alternatives), and jurisdiction (the process whereby response actions are chosen and decisions implemented).

Root, R.T., Knerr, C.M., Severino, A.A., & Word, L.E. Tactical engagement simulation training: A method for learning the realities of combat (ARI Technical Paper 370). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1979.

Problems in measuring military team skills under emergent, ever-changing combat situations were discussed. A list of the data elements recorded under two-sided engagement simulation conditions was presented, as well as the type of summary performance data available from such records.

Scott, T.D., Meliza, L.L., Hardy, G.D., & Banks, J.H. Armor/anti-armor team tactical performance (ARI Research Report 1218). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.

See reference in Section E1. As part of the REALTRAIN validation studies on armor/anti-armor teams, the tactical performance of these teams was observed. Comparison of successful teams vs. unsuccessful teams indicated that the successful units were more effective in planning for the attack, in planning how to deploy their vehicles, to use cover and concealment, etc. Such process measures correlated with mission success.

Shaw, M.E. Scaling group tasks: A method for dimensional analysis. (ONR Contract NR 170-266, nonr-580(1)). Gainesville, Fla.: University of Florida, July 1963. (DTIC No. AD 415 033)

One hundred and four tasks used in small group problem-solving research were scaled on ten dimensions using Thurstone and Chave scaling procedures. The ten dimensions selected were: cooperation requirements, decision verifiability, difficulty, goal clarity, goal path multiplicity, intellectual-manipulative requirements, intrinsic interest, operational requirements, population familarity, and solution multiplicity. Reliability of the resulting scales and the validity of the difficulty scale were examined. Data were factor analyzed in an attempt to determine the actual number of distinct dimensions. Three dimensions were judged to be strong and relatively stable: difficulty (including operational requirements), solution multiplicity (including decision verifiability and goal path multiplicity), and cooperation requirements.

Shaw cautioned that the scale values depend on the homogeneity-heterogeneity of the tasks being scaled. A complete description of each task was presented in the appendix along with the scale values obtained for each task.

Siegel, A.I., & Federman, P.J. Communications content training as an ingredient in effective team performance. Ergonomics, 1973, 16, 403-416.

See reference in Section E1. The first study reported in this document focused on cross-validating the content of communications within helicopter crews. Four factors were examined: the probabilistic structure of the communications, evaluative interchange, hypothesis formulation, and leadership control. The second part of the report focused on evaluating the effects of a team communications program.

Sorenson, J.R. Task demands, group interaction and group performance. Sociometry, 1971, 34, 483-495.

See reference in section C1. The relationship of input, process, and output variables within three-man groups was examined using two types of intellectual tasks (productive vs. problem-solving), five dimensions of group behavior during conduct of the task (structuring, generating, elaborating, evaluating, and requesting), and two output measures (product quality and originality).

Thibaut, J.W., & Kelley, H.H. The social psychology of groups. New York: Wiley, 1959.

See reference in Section B. Three two-dimensional categories for classifying tasks were presented: steady vs. variable states, conjunctive vs. disjunctive tasks, and correspondence vs. noncorrespondence of task outcomes.

Warnick, W.L., O'Brien, R.E., Kraemer, R.E., Healy, R.D., & Campbell, R.C. The validation of the task inventory of the tank company, platoon, and crew and the development of conditions and standards of the task inventory. (Vols. I and II, HumRRO RP-D2-73-4). Alexandria, Va.: Human Resources Research Organization, June 1974. (NTIS Nos. AD A015 599 and AD A015 600)

The method used in developing task inventories for the tank company, platoon, and crew was explained and the resulting task inventories presented. The task inventories included importance ratings for each task or subtask, the company and platoon elements which perform each task, and the conditions and standards for each task. The method involved applying systems engineering to deriving performance requirements for unit training and training test development.

The authors noted that application of the task analytic procedure to unit tasks is quite different from applying the same procedures to

individual tasks. The two most commonly used criteria of individual performance, speed and accuracy, are difficult to apply to unit type tasks. In addition it is important to identify individual tasks which must be performed as part of a unit task (e.g., command decisions). One of the difficulties with military units is defining what a unit task is, since the tasks performed by a unit are constantly confounded with individual tasks and the larger organization with which the unit interacts (e.g., emplacing anti-personnel mines is a typical example of an individual task, but when such devices must be emplaced during the defense of a position, it becomes a unit task). A critical factor in the success of the systems engineering approach was familiarization with the system being examined.

Wheaton, G.R. Development of a taxonomy of human performance: A review of classification systems relating to tasks and performance (AIR-726-12/68-TR-1, Prepared for Advanced Research Projects Agency). Washington, D.C.: American Institutes for Research, December 1968. (DTIC No. AD 689 411)

The author reviewed various efforts to develop a taxonomy of human performance, and focused mainly on the general approaches that have been taken rather than the specific taxonomies that have been developed. One of the problems in classifying tasks is the definition of task itself: tasks can be defined broadly or narrowly and tasks can be defined as being external to or internal to the individual. General approaches to classifying tasks have been based either on the behavior/abilities of the operator or components of the task. The four general approaches that have been defined in the literature are the behavior description approach, behavior requirements approach, ability requirements approach, and task characteristics approach.

The classification procedures must provide reliable classifications, mainly through operational definitions of categories and training of coders. The system may be either qualitative or quantitative in nature. However, qualitative systems do not provide for determining the similarity among tasks. The categories themselves should relate to behavioral effects, and the system as a whole should be efficient and useful.

Williges, R.C., Johnston, W.A., & Briggs, G.E. Role of verbal communication in teamwork. Journal of Applied Psychology, 1966, 50, 477-479.

See reference in Section C1. The authors applied content analytic procedures to communications within two-man aerial control/intercept teams.

U.S. Army Research Institute of Environmental Medicine (USARIEM) Studies on Sustained Operations within Field Artillery Fire Direction Centers

Stokes, J.W., Banderet, L.E. A war for science. Field Artillery Journal, 1978, Jan-Feb, 43-44.

Banderet, L.E., & Stokes, J.W. Interaction process analysis of FDC teams in simulated sustained combat. (Paper presented at a NATO symposium on motivation and morale in Brussels, Belgium). Natick, Mass.: U.S. Army Research Institute of Environmental Medicine, September 1980. (a)

Banderet, L.E., & Stokes, J.W. Simulated, sustained-combat operations in the Field Artillery Fire Direction Center (FDC): A model for evaluating biomedical indices. Proceedings of the Army Science Conference, 1980, 1, 167-181. (b)

Banderet, L.E., Stokes, J.W., Francesconi, R., Kowal, D.M., & Naitoh, P. Artillery teams in simulated sustained combat: Performance and other measures. In L.C. Johnson, D.I. Tepas, W.P. Colquhoun, & M.J. Colligan (Eds.), Variations in work-sleep schedules: Effects on health and performance. Advances in sleep research, Vol. 7. New York: Spectrum Publications, in press.

See reference entry in Section E1. The series of reports on sustained operations within a Field Artillery Fire Direction Center (FDC) illustrates the many types of process variables that can be examined within the team setting as well as the changes in team member interaction that occur under such conditions.

G. EVALUATION OF TEAM AND INDIVIDUAL PERFORMANCE: METHODOLOGY

Instruments, general techniques, and guidelines for measuring/evaluating team performance are cited in this section. Most of the articles focused on military settings.

1. Output Measures

Alluisi, Hall & Chiles (1962)
Baldwin, Frederickson & Hackerson (1970)
Boldovici (1979)
Dees (1969)
Finley et al. (1972)
Giordano et al. (1977)
Glanzer & Glaser (1955)
Glanzer, Glaser & Klaus (1956)
Havron et al. (1955)
Havron et al. (1978-1979)
Horley & Giordano (1970)
Horrocks, Heermann & Kalk (1959)
King et al. (1980)
Knerr, Root & Word (1979)
Larson & Sander (1975)
Medlin & Thompson (1980)
Olmstead et al. (1971)
Schrenk, Daniels & Alden (1969)
Smode, Gruber & Ely (1962)
Sulzen (1980)
Warnick et al. (1974)
Wheaton, Fingerman & Boycan (1978)
USARIEM Studies on Field Artillery FDC (1978-1980)

2. Process Measures

Finley et al. (1969, 1970)
Giordano et al. (1977)
Knerr, Root & Word (1979)
Olmstead et al. (1971)

3. General Procedures for Determining Performance Measures

Boycan & Rose (1977)
Fleishman (1965)
Harris et al. (1975)
Larson & Sander (1975)
Medlin (1979)
Medlin & Thompson (1980)
Mirabella (1978)
O'Brien, Kraemer & Haggard (1975)
Smode, Gruber & Ely (1962)

4. General Recommendations regarding Measurement Selection

Briggs & Johnson (1966a, 1966b)
Connelly, Comeau & Steinheiser (1980)
Glaser & Klaus (1962)
Kubala (1978)
Warnick & Kubala (1978)

Alluisi, E.A., Hall, T.J., & Chiles, W.D. Group performance during four-hour periods of confinement (MRL-TDR-62-70). Wright-Patterson Air Force Base, Ohio: Air Forces System Command, Behavioral Sciences Laboratory, June 1962. (DTIC No. AD 283 842)

The reliability of two measures of crew-group performance were examined. One measure, target identification, stressed individual proficiency, while the other measure, code-lock solving, stressed crew coordination (5-man crew). Subscores on each task had high reliabilities. The authors concluded that it is "feasible to develop

and use crew tasks to measure group performance quantitatively in activities that require interactions among crew members, exchanges of information, cooperation, and coordination" (p. 20).

Baldwin, R.D., Frederickson, E.W., & Hackerson, E.C. Aircraft recognition performance of crew chiefs with and without forward observers (HumRRO Technical Report 70-12). Alexandria, Va.: Human Resources Research Organization, August 1970. (DTIC No. AD 714 213)

This study illustrated one methodological issue that should be considered in conducting team research. A comparison was made of air defense crew recognition of aerial targets with and without the presence of forward observer teams. A simulated environment and ad hoc teams were used. Accuracy of judgment, remaining engagement time, and communication sequence were the primary criterion measures. The analysis showed two types of crew chiefs, those who made decisions earlier when working with crews than when working alone, and those who behaved in the opposite manner. All further analyses were conducted separately for the two groups. Results on the criterion measures varied as a function of the decision-making style of the crew chief. The authors felt that the findings could have occurred because of the ad hoc crews. The men, particularly the forward observers, were not performing in an official military leader-subordinate relationship. Therefore, both the forward observers and the chiefs may not have been motivated to perform to the best of their ability and may not have represented crews experienced in working together on this type of team task.

Boldovici, J.A. Analyzing tank gunnery engagements for simulator based process measurement (ARI Research Report 1227, Performed by Human Resources Research Organization). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Services), September 1979.

See reference in Section F. Measurement procedures were developed for the tank gunner, focusing primarily on speed and accuracy of crew actions.

Boycan, G.G. & Rose, A.M. An analytic approach to estimating the generalizability of tank crew performance objectives (ARI Research Memorandum 77-21). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1977. (DTIC No. AD A077 030)

Previous work had identified a total of 225 performance objectives that could be required of tank crews. Such objectives were of the form: given a stationary M60A1AOS and a moving tank type target of less than 1600 meters either day or night, the crew will engage, using a battlesight method of fire and the gunner's periscope. The present report described a procedure for identifying an optimal subset of objectives to be tested, since it was not feasible to test crews on a large number of objectives.

The approach employed assumed that "the more task elements or behavioral steps that any performance objective has in common with other objectives, the greater the communality among those objectives. Furthermore, the greater the communality, the greater the probability that performance on the one objective is predictive of performance on others" (p. 2). Cluster analysis was used to identify families of performance objectives. A generalizability index was then applied to determine which objectives within a family would be most predictive of performance on the other objectives. The approach could be applied to other team situations where the performance domain is well defined.

Briggs, G.E., & Johnston, W.A. Influence of a change in system criteria on team performance. Journal of Applied Psychology, 1966, 50, 467-472. (a)

See reference in Section E1. Briggs and Johnston showed that the complexity of the criterion measure affected training performance. In particular, when teams had to switch from a simple criterion to a complex one, they continued to emphasize the simple criterion upon which they had been trained, although there was some indication that the teams may have been trying to achieve a compromise between the two criteria. Teams adapted easily when switching from the complex to simple criterion.

Briggs, G.E., & Johnston, W.A. Laboratory research on team training (NAVTRADEVCEN 1327-3). Columbus, Ohio: Ohio State University, May 1966. (b) (DTIC No. AD 485 636)

See reference entry in Section E1. A final recommendation by the authors was that "if complex criteria are found in the evaluation of performance in the operational context, then training should utilize the same complex criteria to facilitate team performance which will be judged acceptable in the operational systems" (p. 27).

Connelly, E.M., Comeau, R.F., & Steinheiser, F. Team performance measures for computerized systems Final Technical Report, Contract # MDA-903-79-C-0274, Conducted for Army Research Institute for the Behavioral and Social Sciences). Vienna, Va.: Performance Measurement Associates, November 1980.

See reference in Section F. Several criteria for team performance measures were cited. Measures must be comprehensive in that they reflect each factor that affects the mission performance of the system. Measures must also be sensitive in that they reveal the effect of mission performance on changes in the performance of individual tasks or types of tasks. Performance measurement must also take into account the fact that a specific task can have a unique effect on total mission performance.

Dees, J.W. Squad performance as a function of the distribution of a squad radio (HumRRO TR 69-24). Alexandria, Va: Human Resources Research Organization, December 1969. (DTIC No. AD 701 152)

See reference in Section E1. Two criterion measures of Infantry squad success were used: time to complete task and ratings of squad proficiency.

Finley, D.L., Obermayer, R.W., Bertone, C.M., Meister, D. & Muckler, F.A. Human performance prediction in man-machine systems (Volume I). A technical review (NASA CR-1614). Canoga Park, Calif.: Bunker-Ramo Corp., August 1970. (STAR N70-35379).

Finley, D.L., Obermayer, R.W., Bertone, C.M., Meister, D. & Muckler, F.A. Human performance prediction in man-machine systems (Volume III). A selected and annotated bibilography (NASA Contract No. NAS2-5038). Canoga Park, Calif.: Bunker-Ramo Corp., August 1969. (STAR N71-27251).

See reference in Section B. The authors cited the need to describe group behavior in either the input, processing, or output stages with such variables as sensitivity or discrimination, manipulation, speed, selection, flexibility, knowledge, memory, general reasoning, deduction or analysis, integration or coordination, prediction or feedback usage, and stamina (p. 95).

Finley, D.L. Rheinlander, T.W., Thompson, E.A., & Sullivan, D.J. Training effectiveness evaluation of Naval training devices Part I: A study of the effectiveness of a carrier air traffic control center training device (Technical Report, NAVTRAEQUIPCEN 70-C-0258-1). Westlake Village, Calif.: Bunker Ramo, Electronic Systems Division, August 1972. (DTIC No. AD 751 556)

See reference in Section E1. Measurement procedures distinguished between team, subteam, and individual performance within a Naval Carrier Air Traffic control training device.

Fleishman, E.A. The prediction of total task performance from prior practice on task components. Human Factors, 1965, 7, 18-27.

Although the study focused on individual rather than team performance, the research paradigm employed may be applicable to team performance. Subjects practiced the components of a three-dimensional task singly and in pairs. Performances on these single and double components were then related to performance on the task as a whole and to each other. The main conclusions were (p. 24): the best predictors of total task and multiple control subtasks were other multiple control subtasks; the particular components involved seemed to be less important than the fact that simultaneous practice had occurred; one particular subtask contributed disproportionately to predicting total task performance; and prior practice on "irrelevant" subtasks may be just as predictive of multiple components performance as "relevant" components.

Part of the explanation of the part-whole relationships found in the study require explanation at a higher level of description: either in terms of common ability requirements among task components or in terms of general habits or behaviors such as scanning, how to share time efficiently, and general patterning of responses.

Giordano, D.J., Ursin, D.J., Zubal, O., & Lutchendorf, T.E. Human Engineering Laboratory Mortar System Test: HELMST-1 (HEL Technical Memorandum 10-77). Aberdeen Proving Ground, Md.: U.S. Army Human Engineering Laboratory, April 1977. (DTIC No. AD B019 699L)

The purpose of this study was to provide baseline performance of the 81mm mortar indirect fire team. Three ground-mounted 81mm mortar platoons were tested during registration and sheaf adjustment missions, shift missions, and polar-pilot missions. No observations were made of the teamwork required by the forward observers, the fire direction center, or the mortar squads. However, observations were made of the coordination among each of these units. Information was provided regarding methodological controls used in evaluation of each unit and the measures of team effectiveness that were obtained.

Glanzer, M. & Glaser, R. A review of team training problems (Prepared for Office of Naval Research). Pittsburgh, Pa.: American Institute for Research, September 1955. (DTIC No. AD 078 434)

See reference in Section F. The authors discussed team measurement problems. Procedures applied to Navy teams were described. Two procedures suggested for assessing teams were the overloading and subtraction methods.

Glanzer, M., Glaser, R., & Klaus, D.J. The team performance record: An aid for team analysis and team training (Technical Report: N7onr-37008, NR-154-079). Pittsburgh, Pa.: American Institute for Research, December 1956. (DTIC No. AD 123 615)

The report described the procedures used to develop the Team Performance Record, an instrument used to pinpoint performance in Navy teams that need improvement and performance that should be encouraged. Team Training Questionnaires, the Team Performance Records, and three preliminary instruments were presented in the appendices. The thirteen behavorial categories in the Team Performance Record were cited, but the record itself, and accompanying instructional manual were not presented in the report.

The thirteen performance categories were:

Availability and readiness of equipment and materials
Composition of group and assignment of members
Briefing and preparation of men
Interest and morale
Safety precautions

Communication procedures and coordination of information
Knowledge of equipment and its operation
Knowledge of performance of individual duties
Judgement and planning
Checking and monitoring
Supervision and leadership
Interchangeability and assistance among team members
Performance in emergencies and damage control

Glaser, R., & Klaus, D.J. Proficiency measurement: Assessing human performance. In R.M. Gagne' & A.W. Melton (Eds.), Principles in system development. New York: Holt, Rinehart & Winston, 1962.

The authors discussed proficiency measurement issues and problems. Although most of the article focused on measuring individual performance, many of the issues discussed apply to measurement of team performance as well. A brief review of four major attempts to measure military group performance that had been conducted at that time (i.e., 1962) was presented. The authors concluded that "assessing the proficiency of multiman systems requires a careful analysis of all variables which may affect group output" (p. 471).

Harris, J.H., Campbell, R.C., Osborn, W.C., & Boldovici, J.A. Development of a model job performance test for a combat occupational speciality. Volume I. Test development (Final Report FR CD (L)-75-6). Alexandria, Va.: Human Resources Research Organization, November 1975. (DTIC No. AD A025 102)

The development and initial testing of a functionally integrated performance test for Armor Reconnaissance Specialist (MOS 11D) was described. A functionally integrated performance test was defined as a job performance test which evaluates not only the soldier's mastery of skills and knowledge, but also his ability to react to stimulus conditions that would be encountered on the job, by embedding tasks within separate testing modules with instructions given only for the first task in each module. Completion of the first task then serves as a stimulus for starting the next task. Individual skills are examined within a team context. Three duty positions within the scout squad were examined: scout observer (11D10), vehicle driver (11D20), and vehicle commander (11D40).

The report described the procedures used to identify critical tasks for each duty position. Performance on these critical tasks was then evaluated. Test development consisted of the following five activities: development of the missions to be completed by the squad, assignment of mission tasks to one or more of the duty positons, establishing the test conditions, determining the dimensions on which performance was assessed, and establishing scoring criteria.

Results focused on interrater reliability on the different tasks examined. Specific suggestions for improving reliability with this form of testing were given. The authors concluded that functionally

integrated performance tests were feasible for combat MOS, however, they are expensive to develop and to use. Although the study focused on the assessment of individual proficiency within a team context, the procedures could be adapted to the evaluation of team skills as well.

Havron, M.D., Gorham, W.A., Nordlie, P.G. & Bradford, R.G. Tactical training of the Infantry rifle squad (HumRRO Technical Report 18). Washington, D.C: Psychological Research Associates, George Washington University, June 1955.

See reference in Section E1. Several measures of Infantry squad performance were developed: two attack missions, two defense missions, two patrol missions, and the leaderless group test.

Havron, M.D. and others. Improved Army Training and Evaluation Program (ARTEP) methods for unit evaluation (7 vols.). (ARI Technical Reports TR-78-A23 through TR-78-A29). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, 1978-1979.

This report series examined ways of improving the Army Training and Evaluation Program (ARTEP) for tank/mechanized battalion-size Infantry units. ARTEPs are used by the military for both training and evaluation purposes. Although most of the suggestions for improving ARTEPs pertained to battalion-size exercises, much of the information in Volume II on Analysis could also be applied to smaller, squad-size units. This volume focused specifically on applying principles from learning theory, systems operations/analysis, job task analysis, psychometrics, and tactical theory to improve the planning and conduct of ARTEP exercises and to increase the learning achieved during such exercises.

Horley, G.L., & Giordano, D.J. Human Engineering Laboratories Battalion Artillery Test: HELBAT I (HEL Technical Memorandum 24-70). Aberdeen Proving Ground, Md.: Human Engineering Laboratories, September 1970.

The purpose of the study was to determine the ability of a battalion of self-propelled howitzers (M109) to deliver surprise fire to a point target. Three artillery battalions were examined. No observations were made of the teamwork required by either the forward observers, the fire direction centers (FDC), or the howitzer sections. However, information was provided regarding evaluation of the effectiveness of each of these teams. For example, data from the FDC were compared to that computed by a control FDC. Locations of targets and of forward observers were predetermined by survey teams. Special filming procedures were used to identify the points of impact of the artillery rounds. Times to complete missions for the teams were compared to Army standards.

Horrocks, J.E., Heermann, E., & Kalk, M. A study of selected factors affecting the measurement of total team product in gunfire support training (Technical Report: NAVTRADEVCEN 1939-0-4). Columbus, Ohio: Ohio State University Research Foundation, November 1959. (DTIC No. AD 643 330)

Two different measures of team performance were compared: assumed error score in which cancelling-out effects of individual errors were eliminated and a resultant error score in which cancelling-out effects could occur. The laboratory tasks examined were based upon tasks performed by Navy gunner crews (CIC-PLOT crews). Three- and five-man teams were required to perform a serial-type mathematical task, with the output of the first individual serving as input to the second individual, etc. Two levels of task difficulty were examined. Teams performed the task 60 times.

Consistency and predictability of team performance were not related to the type of team performance measure. The authors concluded that the criteria for selection of team performance measures must be based on other factors, in particular, convenience and meaningfulness. In light of these two factors, they recommended the resultant error score.

The authors also noted that inconsistency in team performance can be produced by variables other than the criterion measure. In particular, team training may not be of sufficient duration to produce stable performance, individual team members learn at different rates and therefore produce unstable team performance, and monotonous tasks may have a detrimental effect upon individual performance thereby producing unstable team performance.

King, F., Stein, F.S., Sevilla, E.R., & Seed, R.J. Artillery engagement simulation (ARI Technical Report 1245). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, May 1980.

An engagement simulation procedure for Field Artillery batteries, including the FIST (Fire Support Team), the FDC (Fire Direction Center), and the howitzer crew was described. By determining the data actually set on a howitzer gun after a simulated (dry) firing, the corresponding point of impact could be calculated and an artillery simulator placed at the point where a round would land if live ammunition were used. A communication system was established to integrate the artillery battery (FIST, FDC, gun crews) with the artillery engagement simulation (ARES) system (Chief controller, fire makers to place the simulators, gun controllers to observe data on the gun, and a Fire Marker Control Center to calculate the burst locations).

The artillery battery improved its speed, accuracy, and consistency of performance during the simulation. The authors recommended that development of the system should continue --- to validate the system with actual maneuver troops and extend it to other indirect fire systems such as mortars.

Knerr, C.M., Root, R.T., & Word, L.E. An application of tactical engagement simulation for unit proficiency measurement. (ARI Technical Paper 381). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.

The authors discussed problems in measuring team and unit proficiency in field training where modern battle conditions are simulated (as represented by REALTRAIN and ARTEP situations). Objective casuality assessment is the primary focus in such contexts (targets engaged, firer that accomplished the engagement, and time of engagement). However, additional data must be obtained to determine why casualties occurred and to evaluate systems whose missions may be other than target engagement (e.g., target detection, relay of information). Authors stressed the importance of training observers, specifying the behavior to be recorded as concretely as possible, and recording observations immediately. The need to record data on external events that may affect training outcomes was cited (e.g., nature of the opposing forces, missions, weather, terrain), as well as the use of checks or probes to establish the accuracy, completeness and validity of the observations (e.g., establish known location points before the training exercise begins).

Kubala, A.L. Problems in measuring team effectiveness (HumRRO Professional Paper 2-78). Alexandria, Va.: Human Resources Research Organization, January 1978. (DTIC No. AD A049 560)

One of the problems in measuring team effectiveness is that of defining effectiveness; choosing the appropriate MOEs (measures of effectiveness). Examples were given of situations where the wrong MOEs or the exclusion of critical MOEs could have led to the wrong decision about effectiveness. Kubala felt that measurement of performance in a team context should be reserved for only those tasks that are truly team tasks, i.e., "tasks which require cooperation or coordination to the extent that skills must be practiced in a team situation in order to be optimized" (p. 4). The relative merits of one-sided versus two-sided military test situations (without or with aggressor forces) and of process versus outcome measures were discussed. The author concluded that process evaluations are needed to provide feedback to training managers, yet outcome evaluations meet the needs of field commanders. However, it is difficult to obtain process information from a two-sided test and even more difficult to obtain outcome information of the kind desired by commanders from a one-sided test. Further compounding the problem are the limited resources available for even one type of test, much less two types of tests.

Larson, O.A., & Sander, S.T. Development of unit performance effectiveness measures using Delphi procedures (NPRDC TR 72-12). San Diego, Calif.: Navy Personnel Research and Development Center, September 1975. (DTIC No. AD A015 963)

The Marine Corps Tactical Warfare Analysis and Evaluation System (TWAES) involves the recording and evaluation of unit and individual performance in field exercise environments. TWAES requires that contextual factors which moderate performance be considered. Up to the time of the study umpire staffs had made subjective evaluations of such factors. An evaluation system which reduces interjudge variability, provides improved evaluation criteria, and normalizes ratings across units to account for contextual variables was deemed necessary.

In order to meet these goals, response measures which reflected unit effectiveness (e.g., ability to navigate, intelligence gathering, physical condition) and contextual variables which moderate unit performance (e.g., terrain, weather) had to be identified. Judgments on the importance of response and contextual factors were obtained by using the Delphi procedure with a sample of senior field grade officers. Ratings on the response and contextual factors at the individual, team and command levels within squad-company, company-battalion, and battalion-brigade breakdowns were obtained. The next phase of the program is to integrate the response and contextual items into field evaluations to obtain initial reliability and validity data.

Medlin, S.M. Behavioral forecasting for REALTRAIN combined arms (ARI Technical Paper 365). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, May 1979.

The feasibility of board war gaming as a forecasting technique for determining behavioral benchmarks against which unit performance in engagement simulation exercises could be compared was investigated. Situation-specific forecasting was used, meaning that the forecasting was geared to particular exercise conditions (e.g., force ratios, terrain, weapons mix). The pilot study described in the report represented an initial step in assessing the similarities between data collected using the forecasting method and data collected during engagement simulation exercises. A further step, not examined, would have been to have military experts examine the results of each data collection procedure to determine if they could distinguish between the simulated and real data. If not, then the two data sources could be considered identical.

The game players were either captains who were scheduled to serve as company/team commanders in the combined arms engagement simulation itself or lieutenants from the same units who had just participated in the field exercises. Manuever routes of the two opposing forces and casualty data from the war game and field exercise were compared. The author concluded that, in general, the manuever routes seemed comparable, except that the field exercise routes were more complex.

(Field control over unit elements is more difficult than game board control). In general, casualty data were similar as well.

The goal of the ARI program is to validate the forecasting procedure. Once validated, the technique can be used to generate a distribution of outcomes to which engagement simulation outcomes can be compared. "In this manner, the engagement evaluation system will become criterion-referenced, and unit performance in tactical operations can be evaluated systematically and scientifically" (p. 28).

Medlin, S.M., & Thompson, P. Evaluator rating of unit performance in field exercises: A multidimensional scaling analysis (ARI Technical Report 438). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, April 1980.

Scaling techniques were applied to expert military judgement data to explore how military judges evaluate unit performance. In the first part of the study, military judges rated armor/anti-armor unit performances as described in written narratives of 15 field exercises. Multidimensional scaling techniques indicated that three dimensions were used in making these ratings with one dimension being dominant. In the second phase of the study, the nature of these three dimensions was explored by having military judges rank the 15 narratives with respect to twelve attributes. Scaling analyses indicated that the dominant dimension reflected overall performance, and the other two weaker dimensions reflected use of indirect fire and use of TOWs. However, when the best and worst performance narratives were excluded from the analysis, leadership functions and tactical skills appeared as the two secondary factors in judging performance.

The authors recommended replication of the results and further study of the military judgement process. The results could have been a methodological artifact due to the nature of the narratives themselves. On the other hand, the dominant overall performance dimension may have resulted from the fact that all aspects of unit tactical skills may really change in unison, or that judges use a general dimension because they do not know what other dimensions to consider, how to assess performance on other dimensions, or how to assimilate information from other dimensions to arrive at a single evaluation of unit performance.

Mirabella, A. Criterion-referenced system approach to evaluation of combat units (ARI Research Memorandum 78-21). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978.

Various measures of the effectiveness of military units participating in engagement simulation exercises were presented, and their possible relevance to the diagnosis of training deficiencies discussed. In addition, methods for establishing performance standards of units in engagement simulation conditions were cited: ARTEP evaluator/controller

estimations, use of the Delphi technique by military experts, board games, analytic math models, and computer simulation.

The report presented pilot results obtained with ARTEP evaluator/controller estimations. NCOs acting as squad leaders were asked to estimate the performance of rifle squads with varying levels of training in both movement to contact and hasty defense missions. The four levels of training were: only basic combat training, passed level 2 of Infantry ARTEP, passed level 2 of ARTEP and had three or more days of SCOPES training, and combat experienced rangers. The NCOs were given a brief scenario description followed by questions regarding the maximum and minimum distances between fire teams, if the enemy's observation post would be detected prior to crossing a critical phase line, the likelihood of the squad taking the observation post, time estimates for various mission phases, casualty, estimates, etc. Results indicated that NCOs discriminated among training levels, but that there was much variation in their predictions within each training level (i.e., large standard deviations relative to the means).

O'Brien, R.E., Kraemer, R.E., & Haggard, D.F. Procedures for the derivation of mission-relevant unit task statements (HumRRO-TR-75-4). Alexandria, Va.: Human Resources Research Organization, May 1975. (DTIC No. AD A012 673)

A method for systems engineering of unit training was presented. Six major steps were described: system familiarization, mission analysis, task identification, development of task inventories, selection of tasks for training, and task analysis. These steps were applied to three tank units: company, platoon, and crew. Actual development of Army training programs and tests was not addressed, since these tasks are the responsibility of the appropriate Army service schools. Problems associated with the method were summarized.

Olmstead, J. A., Powers, T. R., Caviness, J. A., & Maxey, J. L. Selection and training for small independent action forces: Development of materials and procedures (HumRRO Technical Report 71-17). Alexandria, Va.: Human Resources Research Organization, August 1971.

Small Independent Action Forces (SIAF) are small combat elements designed to carry out operations independent of parent units in insurgency environments. They perform a variety of critical functions and operate under arduous and stressful conditions. The purpose of the report was to describe procedures that had been developed for selecting and training personnel to serve in SIAF units.

A team task motivation questionnaire was used to measure the degree to which a team member was team-oriented or self-oriented. Items were taken from an item pool used previously by C. George at HumRRO in some team training research. Results did show higher team-oriented scores for the special forces than for the control group (not special forces).

One of the criterion proficiency measures used to evaluate the STAF was a performance test composed of sixteen situations that sampled performance in the following areas: use of weapons (e.g., M16A1 rifle, grenade launcher, M60 machine gun), requesting fire support, radio communications, patrolling, battlefield movement, sound detection, helicopter insertion and extraction, land navigation, first aid, human target detection, and physical conditioning. Special sites were constructed for such testing. Limited information on the testing procedures was given.

Schrenk, L.P., Daniels, R.W., & Alden, D.G. Study of long-term skill retention (NAVTRADEVCEN Technical Report 1822-1). St. Paul, Minn.: Honeywell, April 1969. (DTIC No. AD 503 679)

See reference in Section E1. Special tests to evaluate the performance of Navy anti-submarine rocket teams were developed. Parallel forms were created and the tests were also scaled in difficulty.

Smode, A.F., Gruber, A., & Ely, J.H. The measurement of advanced flight vehicle crew proficiency in synthetic ground environments (MRL-TDR-62-2, Prepared for Air Force Systems Command, Behavioral Sciences Laboratory). Stamford, Conn.: Dunlap & Assoc., 1962. (DTIC No. AD 273 449)

The main focus of the document was on measurement issues and problems surrounding crew/team measurement, using flight crew examples and applications. Overall, the report presented major factors that should be considered in the measurement of team performance. The authors indicated that present measures and measurement methods are often inadequate, failing to adequately address such issues as the behaviors that are critical to proficient performance, the best measures of particular activities, the range of conditions under which measures should be taken, etc. Traditional measurement issues (reliability, validity, scale of measurement, subjective vs. objective measures, etc.) were discussed as well as issues uniquely related to team measurement.

The authors stated that the question of what is "crew coordination" remains unanswered. Group dynamics researchers have examinated coordination in terms of member roles and status; other researchers, in terms of tasks, i.e., as individuals in a single-man-machine system where effectiveness is determined by such factors as response adequacy, sequence of performance, and timeliness of behavior. The task-oriented approach was taken by the authors.

Two types of crew coordination were identified: synchronization of action within a crew, referring primarily to mechanical coordination by means of formalized standard operating crew procedures; and crew improvisation reflected in the extent to which members interactively solve problems where there is no standard solution immediately available. The authors speculated that high degrees of both forms of coordination may be reflected in relatively little time spent in interacting and low amounts of communication.

Factors such as the purpose of the team/system can influence measurement aims. Of particular interest was the discussion of how the level of learning of the crew can influence both what is measured and the precision of measurement required.

Six basic steps for developing an effective measurement system were identified: conduct a system and job analysis; identify important and critical tasks; determine performance requirements for the important tasks; select measures appropriate to the behavior to be evaluated; determine conditions under which to measure critical tasks; and decide on techniques for recording measurement data and for combining separate measures. Each of these areas was illustrated with flight crew measures. Seven major classes of measures (on a quantitative-qualitative continuum) were also cited: times, accuracy, frequency of occurrence, amount achieved or accomplished, consumption or quantity used, behavior categorization by observers, and condition or state of the individual in relation to the task. The authors stressed the need to measure performance under various task loadings and under important environmental conditions.

Sulzen, R.H. The effects of repeated engagement simulation exercises on individual and collective performance (Paper presented at American Educational Research Association annual meeting, Boston, Mass.). Alexandria, Va.: Army Research Institute for the Behavioral and Social Sciences, April 1980.

A movement to contact engagement simulation (REALTRAIN) exercise was conducted with a rifle squad in a defensive position and a dismounted platoon as the opposing or enemy force. The same rifle squad participated in 15 exercises, with the membership of the attacking platoon changing from repetition to repetition. Data were collected on both individual performance and on collective (i.e., team, total rifle squad) performance.

Two major indices of collective performance for the rifle squad were developed using casualty data. The first, called an achievement index, considered enemy casualties produced by direct and indirect fire relative to the number of enemy personnel in the exercise. A gradual improvement over time was found with this index. The second index, called a conservation index, considered the avoidance of casualties by the rifle squad. In essence this index represented the survival of the squad. Very little change over time occurred with this index.

Warnick, W.L., & Kubala, A.L. A study of selected problems in armor operations (ARI Technical Report 78-A25). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, November 1978. (DTIC No. AD A065 838)

The fourth section of the report contained a literature review on deriving measures of effectiveness for military teams, and presented current procedures of measuring tank gunnery effectiveness. The authors

concluded that no formal guidelines exist for developing measures of team effectiveness, and that the selection of such measures is primarily intuitive and often guided by expedience rather than logic. Selection of the wrong measures of effectiveness or exclusion of critical measures can lead to wrong decisions about team effectiveness.

The authors discussed the difficulty in distinguishing team from individual tasks, and of determining when the team product is more than the sum of individual efforts. The fuzzy distinction between individual and team skills was illustrated with tank crew tasks. For example, the tank driver must maintain speed and keep the tank as stable as possible. Is this an individual driver skill or does such performance depend upon interaction between the driver and tank commander and/or the driver's knowledge of how the crew performs in particular situations? Another example given was that of acquiring a target. Do crew members scan independently (no teamwork involved) or can search sectors overlap with crew members adapting to each other's shortcomings? In more general terms, difficulties arise when investigators try to operationally define cooperative or interdependent behavior among crew members.

Problems in developing reliable measures of effectiveness, the relative merits of using one-sided versus two-sided tests (i.e., without or with military aggressors) to measure team performance, and the relative merits of process and outcome measures were presented. Finally, some guidelines for developing measures of tank crew effectiveness in areas other than tank gunnery were presented. The critical step in this process involved identifying team tasks and subjecting such tasks to the final judgment of military experts.

Warnick, W.L., O'Brien, R.E., Kraemer, R.E., Healy, R.D., & Campbell, R.C. The validation of the task inventory of the tank company, platoon, and crew and the development of conditions and standards of the task inventory. (Vols. I and II, HumRRO RP-D2-73-4). Alexandria, Va.: Human Resources Research Organization, June 1974. (NTIS Nos. AD A015 599 and AD A015 600)

See reference in Section F. Individual and unit tasks with the tank crew and tank platoon were distinguished. Authors discussed some of the problems in applying traditional task analytic procedures to unit as opposed to individual tasks.

Wheaton, G.R., Fingerman, P.W., & Boycan, G.G. Development of a model tank gunnery test (ARI TR-78-A24). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1978. (DTIC No. AD A061 153)

The procedures used in developing a test of tank crew gunnery performance were described (called a Table VIII in the military community). The methodology used to sample gunner tasks from families of tasks was presented, and has been previously described by Boycan and Rose (1977). General scoring procedures, crew qualification criteria, skill diagnosis, prediction of combat performance from gunnery tests,

and use of gunnery scores for crew motivation were discussed. The report clearly illustrates both the practical problems and theoretical issues involved in measuring team performance in applied settings.

U.S. Army Research Institute of Environmental Medicine (USARIEM) Studies on Sustained Operations within Field Artillery Fire Direction Centers.

Stokes, J.W., & Banderet, L.E. A war for science. Field Artillery Journal, 1979, Jan-Feb, 43-44.

Banderet, L.E., & Stokes, J.W. Interaction process analysis of FDC teams in simulated sustained combat. (Paper presented at a NATO symposium on motivation and morale in Brussels, Belgium). Natick, Mass.: U.S. Army Research Institute of Environmental Medicine, September 1980. (a)

Banderet, L.E., & Stokes, J.W. Simulated, sustained-combat operations in the Field Artillery Fire Direction Center (FDC): A model for evaluating biomedical indices. Proceedings of the Army Sciences Conference, 1980, 1, 167-181. (b)

Banderet, L.E., Stokes, J.W., Francesconi, R., Kowal, D.M., & Naitoh, P. Artillery teams in simulated sustained combat: Performance and other measures. In L.C. Johnson, D.I. Tepas, W.P. Colquhoun, & M.J. Colligan (Eds.) Variations in work-sleep schedules: Effects on health and performance. Advances in sleep research, Vol. 7. New York: Spectrum Publications, in press.

See reference entry in Section E1. The series of reports on sustained operations within a Field Artillery Fire Direction Center (FDC) illustrates the many types of criterion variables that can be examined within a team setting.

H. VARIABLES RELATED TO TEAM BEHAVIOR: METHODOLOGY

Techniques developed for measuring social aspects of the team process are presented in this section. The articles focused on techniques applied to military, rather than small group, situations.

1. Leader Activities

   Lange & Jacobs (1960)

2. Member Perceptions of Each Other

   Cafferty & Streufert (1971)
   McGrath (1961)
   Nelson & Berry (1968)
   Sorenson (1973)

3. Team Motivation

   HumRRO (1971)

4. Sources of Reinforcement

   Eaton (1978)

Cafferty, T.P., & Streufert, S. The group viewed from the vantage point of the individual: Effects of environmental ambiguity on evaluative attitude, perceived competence, and perceived influence of central and peripheral group members (Technical Report No. 38). Lafayette, Ind.: Purdue University, April 1971. (DTIC No. AD 722 786).

The authors examined the influence, competency, and overall evaluation of group members as perceived by other group members. Results showed that in an ambiguous environment (ie., little relevant information related to group tasks is provided) a central group member was perceived as having greater influence than a peripheral group member. Similar ratings occurred on the evaluative and competency dimensions. The authors concluded that the results suggested that a more ambiguous environment works in favor, of a central group member and to the detriment of a peripheral group member in terms of the relative power each can exert on an individual who interacts with them on a joint task. Use of such internal ratings within the military context may provide an additional perspective on the behavior of military teams.

Eaton, N.K. Performance motivation in armor training (ARI Technical Paper 291). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, Ft. Knox Field Unit, September 1978. (DTIC No. AD A064 247).

See reference in Section D. An instrument was developed to measure the sources of rewards available to armor crewmen, ranging from recognition, tangible rewards, intrinsic rewards, to self-actualization. Relationships among motivation subscores and between the motiva-

tion scores and tank crew gunner performance were examined. Although the source motivation instrument focused on individual motivation/rewards, similar techniques could be developed for team-level motivation/rewards.

Hackman, J. R. Tests, questionnaires and tasks of the group effectiveness research laboratory (Technical Report No. 24, ONR Contract NR 177-472, NONR-1834(36)). Urbana, Ill.: Group Effectiveness Research Laboratory, University of Illinois, July 1965. (DTIC No. AD 623 312)

This report described briefly the tests, questionnaires and tasks used in the study of small group research at the Group Effectiveness Research Laboratory from 1951-1964. The instruments were used in projects supported by the Office of Naval Research and the Advanced Research Projects Agency.

HumRRO. SIAF selection procedures (HumRRO RBP-04-71-36). Alexandria, Va.: Human Resources Research Organization, Division No 4, Ft. Benning, Ga., December 1971.

The document presented the tests which comprised the SIAF Selection Battery, a battery designed to predict the probability that an individual would be successful in complete Small Independent Action Forces (SIAF) training and would be effective in his performance in SIAF operations. One of the instruments was designed to measure motivation for teamwork, called the Team Task Motivation Questionnaire (TTMQ). The TTMQ consists of twenty-four two-choice items, some of which focus directly on Infantry squads and platoons but could be modified for other types of Army teams. This questionnaire was cited by George et al. (1963) and Olmstead et al. (1971) in their studies of Infantry squads.

Lange, C.J., & Jacobs, T.O. Leadership in Army Infantry platoons: Study II (HumRRO Research Report 5). Alexandria, Va.: George Washington University, Human Resources Research Office, July 1960. ((DTIC No. AD 240 895).

The reliability and validity of the Leader Activities Questionnaire (for Infantry platoon leaders) were examined. The questionnaire was composed of seven leadership dimensions: defining, pre-task motivation, post-task motivation, handling disruptive influences, getting information, NCO use and support, and other activities. Four criterion variables were used: subordinates' ratings of platoon leader, subordinates' rating of platoon, subordinates' belongingness questionnaire, and superior's rating of platoon leader. Validity coefficients for the leadership dimensions were similar to those obtained in previous studies and were judged satisfactory. More information on each of these dimensions can be found in Jacobs, T.O. Basic problems in small-unit leadership. Fort Benning, Ga.: HumRRO Division No. 4, April 1965. (DTIC No AD 637 727).

McGrath, J.E. <u>Assembly of quasi-therapeutic rifle teams</u> (Technical Report No. 13). Urbana, Ill.: University of Illinois, Department of Psychology, Group Effectiveness Research Laboratory, July 1961. (DTIC No. AD 680 204).

See reference in Section D. McGrath measured the extent to which an individual perceived a teammate as warm, supportive and accepting. This instrument was presented in an appendix.

Nelson, P.D. & Berry, N.H. Cohesion in Marine recruit platoons. <u>Journal of Psychology</u>, 1968, <u>69</u>, 63-71. (DTIC No. AD 667 615)

A mathematical procedure for estimating the degree of cohesion from sociometric interpersonal choice data within Marine Corps platoons was presented. Cohesiveness remained moderately stable from the second to the tenth week of training with the most cohesive platoons at the end of training being those whose membership remained intact throughout training. Dyads were the most frequent substructure within platoons. Cohesiveness was related to the homogeneity of the platoon members' age, platoon members' education, and geographical region of residence. Cohesiveness did not correlate with individual member performance, but did correlate moderately with positive attitudes toward the Marine Corps. No measures of platoon effectiveness were obtained.

Sorenson, J.R. Group member traits, group process, and group performance. <u>Human Relations</u>, 1973, <u>26</u>, 639-655.

Sorenson's model of group process assumes that task demands act both directly and indirectly, through member traits, to shape group task behavior, which in turn shapes the quality of group performance. The experimental design of this study illustrates one way of examining such effects. Since the particular traits investigated (remote associates proficiency and cognitive social differentiation) are not viewed as particularly crucial to military teams, the study results are not presented. Sorenson created four groups composed of members that varied on two traits (high-high group, two high-low groups, low-low group). Each type of group was exposed to two types of problem-solving tasks on which two measures of group performance were obtained. Five measures of group behavior during the problem-solving activity were also measured. Performance differences among the four groups were examined, with the process variables and initial trait differences used to explain performance differences.

I. STATE OF THE ART REPORTS

The following articles describe needed theoretical and conceptual developments within the small group/team field, questions that need to be investigated in future research efforts, recent technological and/or theoretical developments that might yield a pay-off for team research and training, and needed methodological changes. These articles are based on both team and small group research efforts.

1. Theoretical and Conceptual Needs

Borgatta et al. (1959)
McGrath & Altman (1966)
Goldin & Thorndyke (1980)

2. Research Questions to Address

Borgatta et al. (1959)
Goldin & Thorndyke (1980)
Hackman & Morris (1975)
McGrath & Altman (1966)
Meister (1976)
Thorndyke & Weiner (1980)
Wagner et al. (1977)

3. Methodological Improvements

Borgatta et al. (1959)
Hackman & Morris (1975)
McGrath & Altman (1966)

4. Application of Technology

Defense Science Bd. (1976)
Hood et al. (1960)
Popelka & Knerr (1980)
Thorndyke & Weiner (1980)

Borgatta, E. F., Lanzetta, J. T., McGrath, J. E., & Strodtbeck, F. L. Report of the task group on team functions. (Report submitted to the Office of Science, Director of Defense Research and Engineering). Washington, D.C.: Smithsonian Institution, Research Group in Psychology and the Social Sciences, August 1959. (DTIC No. AD 283 329)

The task force report on team functions described the current state of team research, pointed to areas that need to be studied in more depth, and made general recommendations regarding future military investments in the area of team research. Described below are the major research needs identified by the task force.

Systematic study is required of the amount of variance in team productivity that can be accounted for by team composition, organization, and training, as well as the amount of degradation contributed by poor composition and organization that can be overcome by manipulation of other variables (p. 5)

Systematic attention must be given to team effectiveness criteria, i.e., how well the team does what it is assigned to do, the extent to

which the team's performance outputs contribute to the overall task or mission of the larger system of which it is a part, and the contribution of member performances to total team performance (p.8). Measures of final output as well as measures of intermediate output should be examined. Few studies have attempted to relate criterion effectiveness to measures of group process or interaction (p.9).

Group research has tended to overlook the importance of task and situation variables. Yet it is generally recognized that many of the research questions in the team area are intelligible only when one knows the task performed, and that team research findings have a very narrow range of generalization. Research is needed on task dimensions that would allow generalizable predictions from team research (p. 11).

No one has yet demonstrated convincingly that the composition of a team has an important effect upon team efficiency. Research is needed to identify the conditions which maximize the importance of team composition factors and to identify the individual traits and rules for composing a team so that group process and/or products are maximized (p. 14). Most studies have examined personality dimensions rather than skill variables, and few studies have examined both personality and skill variables (p. 16).

There is a lack of adequate theory, method, and data to provide guidance in the selection of training problems and research approaches. The task force felt that this dearth of information will probably continue unless military support is given, since few civilian agencies appear to have a need to generalize to a variety of teams and hence few support research on problems other than those related to human relations training. Future support is needed to help develop principles applicable to the training of teams to operate multi-man-machine systems; to develop an adequate theory of group learning; to investigate relationships between situation and/or task demands and team training requirements; to determine optimal lengths and phases of individual and team training; and to examine factors affecting the degree of transfer from training tasks to operational ones (p. 20).

Defense Science Board. Summary report of the task force on training technology. Washington, D.C.: Office of the Director of Defense Research and Engineering, 1976. (See also, Alluisi, E.A. Lessons from a study of defense training technology. Journal of Educational Technology Systems, 1976, 5, 57-77.)

See reference in Section E2. The board stressed the need to apply developments in training technology to crew/group/team/unit training.

Hackman, J.R., & Morris, C.G. Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol. 9). New York: Academic Press, 1975, pp. 45-99. (DTIC No. AD 785 287)

See reference in Section B. In this article Hackman and Morris identified some research needs: examine process-performance relationships and input-process performance relationships, with a focus on group interactions critical to group effectiveness in addition to describing what happens within a group. Sequences of interaction, rather than summary frequencies or rates of interaction, need to be recorded and related to task goals and strategies. Procedures that permit analysis of more than two people over relatively long periods of time should be developed. A system for categorizing small group tasks needs to be developed, and process-performance relationships should then be examined within classes of tasks.

Hood, P.D. and others. Conference on integrated aircrew training. (WADD Technical Report 60-320). Wright-Patterson Air Force Base, Ohio: Air Research and Development Command, Wright Air Development Division, July 1960. (DTIC No. AD 240 688)

See reference in Section A. The latest developments in aircrew simulators were presented. Both software and hardware needs were discussed. (Note the 1960 date of the report.)

Goldin, S.E., & Thorndyke, P.W. (Eds.) Improving team performance: Proceedings of the Rand team performance workshop (R-2606-ONR). Santa Monica, Calif.: Rand Corporation, August 1980.

The series of papers presented at the workshop related to team performance, research on teams, and team training. The value of the papers resides primarily in the variety of perspectives presented. The term "team" was broadly defined; no restrictions on team size nor team purpose/function were presented. Given below is an outline of the topics discussed at the workshop.

Gaming and Simulation

a. Discussion of simulators/training devices presently used in Navy team training.

b. Research issues related to such training programs (e.g., performance feedback, forms of coordination).

c. Problems in evaluation of Naval team performance in the field and in school.

d. Problems with clearly defining skills for positions within a team.

e. Standardization in training programs and devices.

f. Diagnosis of training needs, considering both interactions within and between teams, especially teams whose actions depend upon the actions of an opponent.

g. Problems in design of simulation-based training, e.g., degree of real-world fidelity, programming difficulty levels of team tasks.

Organization Theory

a. Human information processing approaches to teams: defining dimensions of task environments that generalize from task to task, key results from human cognition research that might be applicable to team research, study of a team's representation/model of the situation upon which it acts, resistance to change of such definitions of the situation.

b. Problems in lack of agreement among individuals from various disciplines in their use of team constructs.

c. Importance of obtaining a better understanding of team outcomes.

d. Investigation of process approaches to organization design rather than structural determinants of organizational effectiveness.

Small Group Processes

a. Study of polarization of opinions in stable, face-to-face decision making or problem solving teams.

Cognitive Psychology

a. Goal analysis of team situations.

b. Analysis of communication failures within teams and of continuing dialogues within teams.

c. Development/application of various problem-solving models to teams.

d. Use of analysis of covariance structures in team evaluation.

Training and Instruction

a. Assessment of instructional needs as the critical aspect in instructional design.

b. Development of multiple criteria that reflect team performance, and use of creative evaluation designs in the field.

c. Extension of personal computing paradigms to cooperative computing environments.

Heuristic Modeling

a. Discussion of how recent developments in artificial intelligence might be applied to the psychology of teams.

b. Possible applications of heuristic modeling: creation of an institutional memory, management of the training/gaming context, training managment (coaching, scenario control, evaluation), and organizational engineering.

Decision Theory

a. Presentation of basic decision theory concepts within the context of team decision-making, stressing such concepts as skills, resources, goals and values.

b. Possible research strategies for studying team decision-making.

Human Engineering

a. Teleconferencing research.

b. Need for human factors engineers to determine whether a team is required, if at all.

c. Need to define "teamness"; definitions are presently restricted to the dimensions of interaction and communication.

d. Recommended study of the development of teams when new military systems are introduced in the field.

e. Questions the user should address during system development: what can be done with system design to increase/decrease "teamness", how can teams be organized to maximize their efficiency, how can team efficiency be measured apart from single operator measures.

McGrath, J.E., & Altman, I. Small group research: A synthesis and critique of the field. New York: Holt Rinehart & Winston, 1966.

See reference in Section A. McGrath and Altman cited research questions that had not been investigated with small group research as well as methodological weaknesses. Most of the methodological weaknesses also apply to team research: failure to replicate studies, lack of a common language, little research that systematically

progresses from the lab to the field, no longitudinal studies on team development, and lack of theory.

Meister, D. Behavioral foundations of system development. New York: Wiley, 1976.

See reference in Section A. Meister's two chapters on task characteristics and team functions summarized team research conducted prior to 1976. Research questions not addressed by such studies were raised. These questions were: what types of nonverbal interactions occur within teams; are such interactions trainable; how do interactions reflect team performance and what is the effect of communication upon system ouput; how do you determine who is in a team; how do you determine what is a measureable unit of team activity; how homogeneous does a team have to be; what is the effect of turnover in personnel and does this effect vary with skills required and type of task; are contributions of team members to output variables equal or differentially weighted and how can we explain this; how well can we predict team and system output from the combined performance of individual team members; what is being learned when a team is being trained as a team (if we can't specify this, then we can't control training nor plan for it); does team training exhibit the same characteristics as individual training; what is the relationship between individual and team training; does team training really improve system output; and are the major variables that influence individual training (e.g., type of task, feedback, learning ability) the same as those that influence team training.

Popelka, B.A., & Knerr, C.M. Team training applications of voice processing technology (Final Report, ARPA Contract No. MDA903-79-C-0209). Springfield, Va.: Litton Mellonics Systems Development Division, March 1980. (DTIC No. AD A085 999/1)

Laboratory studies of team performance indicate that team performance decreases as communication and interactive demands among team members increase. When team communications and interactions are primarily verbal, automated speech technology and intelligent computer assisted instruction may offer excellent vehicles for team training. The report investigated the state of voice processing technology and reviewed several early training applications of this technology.

Although the area of automated speech generation is well developed and commonly applied, the area of automated speech recognition is still in the developmental stages. Until automated speech recognition technology is improved, the application of voice processing to team training situations that involve other than restricted, stylized communications will be limited. The Navy has used voice processing technology in prototype training settings for the Group Controlled Approach Controller Training System and Air Intercept Controller

training. The authors suggested that artillery sections and tank crews are two Army teams that could profit from such voice technology.

Thorndyke, P.W., & Weiner, M.G. Improving training and performance of Navy teams: A design for a research program (R-2607-ONR). Santa Monica, Calif.: Rand Corporation, July 1980. (DTIC No. AD A089 092/1).

The purposes of the Office of Naval Research project were to address research needs in the areas of team training, development and evaluation, and to design a research program aimed at the improvement of Navy team effectivenes. One of the recommendations in the report was that a research program that focused on a coordinated, in-depth study of a selected team or type of team would provide the best chance of producing usable results for the Navy. In particular, teams that "process large amounts of symbolic information and make tactical decisions under considerable time stress" (p. v) (e.g., teams in tactical flag command centers, combat information centers, anti-submarine warfare centers) were recommended.

Three classes of research efforts were identified that could lead to improvements in team effectiveness: organizational policy studies focusing on Naval policies and plans that affect team performance, translation of existing knowledge and technologies to team operations, and new studies of team performance including laboratory studies, theory development, simulations and games investigating team interactions, and research on various software aids for performance modeling, training and improving task performance. In this last category, many research suggestions were made that could be applied to all military teams. These areas are briefly cited below.

a. Development of improved performance models and evaluation techniques to include cognitive models of individual performance, team members' mental models of task performance, relationship between individual and team performance, and theories of team performance.

b. Investigation of team synergy and turnover including the stages and processes underlying the evolution of a team, and effects of turnover on performance.

c. Improvement of team organization to include task allocation and restructuring, and alternative decision making and communication strategies.

d. Improvemment of team training to include "intelligent" computer-assisted instruction for team training, training of mental models of the team's mission/task held by team members, training emphathetic models regarding the role of other team members and understanding of team members as individuals, training flexibility in SOP-based performance, use of dynamic

gaming as a training aid, and enriching feedback in training and operational environments.

e. Man-machine systems for task performance including use of automated specialists to supplement or replace team members, automated planning aids for decision making, and machine aids for cooperative problem-solving.

Wagner, H., Hibbits, N., Rosenblatt, R. D., & Schulz, R. Team training and evaluation strategies: State-of-the-art (HumRRO-TR-77-1). Alexandria, Va.: Human Resources Research Organization, February 1977. (DTIC No. AD A038 505)

See reference in Section A. Recommendations for future team research were identified, e.g. what is the best way to provide team feedback, what degree of simulation fidelity is needed for training, what sequence of individual and team skill training is most effective.

REFERENCES

	Page	Section
Alexander, L. T., Kepner, C. H., & Tregoe, B. B. The effectiveness of knowledge of results in a military system-training program. Journal of Applied Psychology, 1962, 46, 202-211.	146	F1
Alexander, L. T. & Cooperband, A. S. System training and research in team behavior (TM-2581). Santa Monica, Calif.: System Development Corporation, August 1965. (DTIC No. AD 620 606)	43, 71	A, B
Alluisi, E.A., Hall, T.J., & Chiles, W.D. Group performance during four-hour periods of confinement (MPL-TDR-62-70). Wright-Patterson Air Force Base, Ohio: Air Forces System Command, Behavioral Sciences Laboratory, June 1962. (DTIC No. AD 282 342)	207	G
Altman, I. Aspects of the criterion problem in small group research. I. Behavioral domains to be studied. Acta Psychologica, 1966, 25, 101-131. (a) (DTIC No. AD 633 248)	185	F
Altman, I. Aspects of the criterion problem in small group research. II. The analysis of group tasks. Acta Psychologica, 1966, 25, 199-221. (b)	185	F
Altman, I. The small group field: Implications for research on behavior in organizations. In R. V. Bowers (Ed.), Studies on behavior in organizations. Research symposium. Athens, Ga.: University of Georgia Press, 1966, pp. 64-86. (DTIC No. AD 647 091)	44	A

	Page	Section
Baldwin, R. D., Frederickson, E. W., & Hackerson, E. C. *Aircraft recognition performance of crew chiefs with and without forward observers* (HumRRO Technical Report 70-12). Alexandria, Va.: Human Resources Research Organization, August 1970. (DTIC No. AD 714 212)	208	G
Baker, R.A., Cook, J.C., Warnick, W.L., & Robinson, J.P. *Development and evaluation of systems for the conduct of tactical training at the tank platoon level* (HumRRO Technical Report 88). Alexandria, Va.: Human Resources Research Office, April 1964.	147	E1
Banderet, L.E., & Stokes, J.W. *Interaction process analysis of FDC teams in simulated sustained combat.* (Paper presented at a NATO symposium on motivation and morale in Brussels, Belgium). Natick, Mass.: U.S. Army Research Institute of Environmental Medicine, September 1980. (a)	172, 206, 222	E1, F, G
Banderet, L.E., & Stokes, J.W. Simulated, sustained-combat operations in the Field Artillery Fire Direction Center (FDC): A model for evaluating biomedical indices. *Proceedings of the Army Science Conference*, 1980, *1*, 167-181. (b)	172, 206, 222	E1, F, G
Banderet, L.E., Stokes, J.W., Francesconi, R., Kowal, D.M., & Naitoh, P. Artillery teams in simulated sustained combat: Performance and other measures. In L.C. Johnson, D.I. Tepas, W.P. Colquhoun, & M.J. Colligan (Eds.), *Variations in work-sleep schedules: Effects on health and performance. Advances in sleep research*, Vol. 7. New York: Spectrum Publications, in press.	173, 206, 222	E1, F, G
Banks, J. H., Hardy, G. D., Scott, T. D., & Jennings, J. W. *Elements of a battalion integrated sensor system: Operator and team effectiveness* (ARI Research Report 1187). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Ord Field Unit, December 1975. (DTIC No. AD A025 811)	91	C1

	Page	Section
Banks, J.H., Hardy, G.D., Scott, T.D., Kress, G. & Word, L.E. *REALTRAIN validation for rifle squads: Mission accomplishment* (ARI Research Report 1192). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, October 1977. (DTIC No. AD A043 515)	169	E1
Berger, D. C., Knerr, C. M., & Popelka, B. M. *A systems model of team performance.* Paper presented at the Annual Convention of the American Psychological Association, Division 19 (Military Psychology), New York City, August 1979.	59	A
Berkowitz, L. & Levy, B. I. Pride in group performance and group-task motivation. *Journal of Abnormal and Social Psychology*, 1956, *53*, 300-306.	92	C1
Bialek, H.M., Taylor, J.E., & Hauke, R.N. *Instructional strategies for training men of high and low aptitude* (HumRRO Technical Report 73-10). Alexandria, Va.: Human Resources Research Organization, April 1973.	175	E2
Biel, W. C., Chapman, R. L., Kennedy, J. L., & Newell, A. *The systems research laboratory's air defense experiments* (P-1201). Santa Monica, Calif.: Rand Corporation, October 23, 1957. (DTIC No. AD 606 273)	147	E1
Billings, A. G., McDowell, S. W., Gomberg, C. A., Kessler, M. & Weiner, S. The validity of time-sampling in group interactions. *Journal of Social Psychology*, 1978, *104*, 223-230.	186	F
Blades, J.W., & Fiedler, F.E. *The influence of intelligence, task ability, and motivation on group performance* (Technical Report 76-78). Seattle, Wash.: University of Washington, Department of Psychology, January 1976. (DTIC No. AD A021 223)	135	D
Bleda, P. R. & Hayes, J. *Impact of REALTRAIN and conventional combined arms exercises on participant morale* (ARI Technical Paper 308). Alexandria, Va.: U. S. Army Research Institute for the Behavioral and Social Sciences, August 1978.	172	E1

	Page	Section
Bleda, P.R., & Sulzen, R. H. The effects of simulated Infantry combat training on motivation and satisfaction. *Armed Forces and Society*, 1980, *6*(2), 202-214.	172	E1
Boguslaw, R., & Porter, E. H. Team functions and training. In R. M. Gagne (Ed.), *Psychological principles in systems development*. New York: Holt, Rinehart & Winston, 1962, pp. 387-416.	44, 71, 175	A, B, E2
Boldovici, J. A. *Analyzing tank gunnery engagements for simulator-based process measurement* (ARI Research Report 1227. Performed by Human Resources Research Organization). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1979.	186, 208	F, G
Bolin, S.F., Sadacca, R. & Martinek, H. *Team procedures in image interpretation* (Technical Research Note 164). Washington, D.C.: U.S. Army Personnel Research Office, December 1965. (DTIC No. AD 480 533)	163	E1
Bons, P.M., & Fiedler, F.E. *The effect of changes in command environment on the behavior of relationship- and task-motivated leaders* (TR 75-53). Seattle, Wash.: University of Washington, January 1975. (DTIC No. AD A021 495)	126	C2
Borgatta, E. F., Lanzetta, J. T., McGrath, J. E., & Strodtbeck, F. L. *Report of the task group on team functions* (Report submitted to the Office of Science, Director of Defense Research and Engineering). Washington, D. C.: Smithsonian Institution, Research Group in Psychology and the Social Sciences, August 1959. (DTIC No. AD 283 320)	226	I
Bowen, D.D., & Siegel, J.P. Process and performance: A longitudinal study of the reactions of small task groups to periodic performance feedback. *Human Relations*, 1973, *26*, 433-448.	93	C1
Boycan, G.G., & Rose, A.M. *An analytic approach to estimating the generalizability of tank crew performance objectives* (ARI Research Memorandum 77-21). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1977. (DTIC No. AD A077 030)	208	G

	Page	Section
Briggs, G. E., & Johnston, W. A. <u>Team training research</u> (Technical Report, NAVTRADEVCEN 1327-2). Columbus, Ohio: Human Performance Center, Ohio State University, November 1965. (DTIC No. AD 477 963)	165	E1
Briggs, G. E. & Johnston, W. A. Influence of a change in system criteria on team performance. <u>Journal of Applied Psychology</u>, 1966, <u>50</u>, 467-472.(a)	148, 209	E1,G
Briggs, G.E., & Johnston, W.A. <u>Laboratory research on team training</u> (NAVTRADEVCEN 1327-3). Columbus, Ohio: Ohio State University, May 1966. (DTIC No. AD 485 636). (b)	166, 187, 209	E1, F, G
Briggs, G. E., & Johnston, W. A. Stimulus and response fidelity in team training. <u>Journal of Applied Psychology</u>, 1966, <u>40</u>, 114-117.(c)	165	E1
Briggs, G. E. & Johnston, W. A. <u>Team training</u> (Technical Report: NAVTRADEVCEN 1327-4). Columbus, Ohio: Ohio State University, Human Performance Center, June 1967. (DTIC No. AD 660 019)	45, 92, 164, 176	A,C1, E1,E2
Briggs, G. E., & Naylor, J. C. <u>Experiments on team training in a CIC-type task environment</u> (Technical Report, NAVTRADEVCEN 1327-1). Columbus, Ohio: Ohio State University, Laboratory of Aviation Psychology, June 1964. (DTIC No. AD 608 309)	164	E1
Briggs, G. E., & Naylor, J. C. Team versus individual training, training fidelity, and task organization effects on transfer performance by three-man teams. <u>Journal of Applied Psychology</u>, 1965, <u>49</u>, 387-392.	165	E1
Brown, R. L. <u>A content analysis of communications within Army small-unit patrolling operations</u> (HumRRO Technical Report 67-7). Alexandria, Va.: George Washington University, Human Resources Research Office, Division No.4, Fort Benning, Ga., June 1967.	187	F
Buehler, R.E., & Richmond, J.F. Interpersonal communication behavior analysis: A research method. <u>Journal of Communication</u>, 1963, <u>13</u>, 146-155.	188	F

	Page	Section
Cafferty, T.P., & Streufert, S. The group viewed from the vantage point of the individual: Effects of environmental ambiguity on evaluative attitude, perceived competence, and perceived influence of central and peripheral group members (Technical Report No. 38). Lafayette, Ind.: Purdue University, April 1971. (DTIC No. AD 732 786)	223	H
Caviness, J.C., & Titus, T.L. KC-135 aircrew management. Maxwell Air Force Base, Ala.: Air University, May 1977. (DTIC No. AD B020 444L)	177	E2
Chapman, R. L., Kennedy, J. L., Newell, A., & Biel, W. C. The systems research laboratory's air defense experiments. Management Science, 1959, 5, 250-269.	147	E1
Clark, R.A. Analyzing the group structures of rifle squads in combat. In Collected papers prepared under work unit INTERSQUAD: A study of the factors which account for the differences between effective and ineffective rifle squads. (HumRRO Professional Paper 8-69). Washington, D.C.: George Washington University, Human Resources Research Office, March 1969, pp. 16-24. (a) (DTIC No. AD 686 621)	189	E
Clark, R. A. Developing a functional theory of leadership. In Collected papers prepared under work unit INTERSQUAD: A study of the factors which account for the differences between effective and ineffective rifle squads. (HumRRO Professional Paper 8-69). Washington, D. C.: George Washington University, Human Resources Research Office, March 1969, pp. 25-31. (b) (DTIC No. AD 686 621)	127, 136	C2, D
Cockrell, J.T. Maintaining image interpreter proficiency through team consensus feedback (BESRL Technical Research Note 195). Washington, D.C.: U.S. Army Behavioral Science Research Laboratory, April 1968. (DTIC No. AD 833 583)	163	E1

	Page	Section
Cockrell, J. T. Maintaining target detection proficiency through team consensus feedback (BESRL Technical Research Note 219). Arlington, Va.: U.S. Army Behavioral Science Research Laboratory, December 1969. (DTIC No. AD 707 376)	163	E1
Cockrell, J.T., & Sadacca, R. Training individual image interpreters using team consensus feedback (BESRL Technical Research Report 1171). Arlington, Va.: U.S. Army Behavioral and Systems Research Laboratory, June 1971. (DTIC No. AD 747 827)	163	E1
Collins, J. J. A study of potential contributions of small group behavior research to team training technology development. Alexandria, Va.: Essex Corporation, August 1977. (DTIC No. AD A043 911)	49	A
Connelly, E.M., Comeau, R.F., & Steinheiser, F. Team performance measures for computerized systems Final Technical Report, Contract #MDA-903-79-C-0274, Conducted for Army Research Institute for the Behavioral and Social Sciences). Vienna, Va.: Performance Measurement Associates, November 1980.	189, 209	F,G
Crawford, M. P. (Ed.). Psychological research on operational training in the Continental Air Forces (Army Air Forces Aviation Psychology Program, Research Report No. 16). Washington, D. C.: Army Air Forces, 1947. (DTIC No. AD 651 792)	136	D
Crawford, M. P. A review of recent research and development on military leadership, command, and team function (HumRRO Research Memorandum). Alexandria, Va.: Human Resources Research Office, George Washington, University, September 1964. (DTIC No. AD 478 283)	49	A
Daniels, R. W., Alden, D. G., Kanarick, A. F., Gray, T. H., & Feuge, R. L. Automated operator instruction in team tactics (NAVTRADEVCEN 70-C-0310-1). St. Paul, Minn.: Honeywell, January 1972. (NTIS No. AD 736 070)	50, 177, 190	A, E2, F
Dees, J. W. Squad performance as a function of the distribution of a squad radio (HumRRO TR 69-24). Alexandria, Va.: Human Resources Research Organization, December 1969. (DTIC No. AD 701 152)	148, 210	E1,G

	Page	Section
Defense Science Board. Summary report of the task force on training technology. Washington, D.C.: Office of the Director of Defense Research and Engineering, 1976. (See also, Alluisi, E.A. Lessons from a study of defense training technology. Journal of Educational Technology Systems, 1976, 5, 57-77.)	177, 227	E2,I
DeLuca, A. J., & Wagner, G. J. Critical combat performances, knowledges, and skills required of the Infantry rifle platoon leader: Squad formation, battle drill, and elementary fire and maneuver. Washington, D. C.: George Washington University, Human Resources Research Office, June 1968. (DTIC No. AD 704 047)	71	B
Denson, R. W. Team training: Literature review and annotated bibliography (AFHRL-TR-80-40). Wright Patterson Air Force Base, Ohio: Logistics and Technical Training Division, Air Force Human Resources Laboratory, May 1981.	51	A
Dieterly, D.L. Team performance: A model for research. In E.J. Baise & J.M. Miller (Eds.), Proceedings of the Human Factors Society, 22nd Annual Meeting. Santa Monica, Calif.: Human Factors Society, 1978.	71, 190	B,F
Doten, G.W., Cockrell, J.T., & Sadacca, R. The use of teams in image interpretation: Information exchange, confidence, and resolving disagreements (Technical Research Report 1151). Washington, D.C.: U.S. Army Personnel Research Office, October 1966. (DTIC No. AD 643 312)	163	E1
Doten, G.W., & Sadacca, R. Team interpretation procedures: Selection of teammates and role assignment (BESRL Technical Research Note 201). Arlington, Va.: U.S. Army Behavioral Science Research Laboratory, January 1969. (DTIC No. AD 688 140)	163	E1
Dyer, J.L. The initial training of individual and team skills: An exploratory investigation of Engineer bridge specialists (ARI Working Paper, FBNG FU 80-1). Fort Benning, Ga.: U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Benning Field Unit, October 1980.	149, 190	E1,F

	Page	Section
Dyer, J.L. Prediction of Infantry squad errors during training: Pilot investigation (ARI Technical Report). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, in press.	178	E2
Dyer, J.L., Tremble, T.R., & Finley, D.L. The structural, training, and operational characteristics of Army teams (ARI Technical Report 507). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, June 1980.	137	D
Eaton, N.K. Performance motivation in armor training (ARI Technical Paper 291). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, Ft. Knox Field Unit, September 1978. (DTIC No. AD A064 247).	94, 223	C1,H
Eaton, N. K., & Neff, J. F. The effects of tank crew turbulence on tank gunner performance (ARI Technical Paper 350). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978.	95	C1
Egerman, K. Effects of team arrangement on team performance: A learning-theoretic analysis. Journal of Personality and Social Psychology, 1966, 3, 541-550. (DTIC No. AD 635 700)	124	C1
Egerman, K., Glaser, R. & Klaus, D.J. Increasing team proficiency through training. 4. A learning-theoretic analysis of the effects of team arrangement on team performance (AIR-B64-9/63-TR). Pittsburgh, Pa.: American Institute for Research, September 1963. (DTIC No. AD 422 328)	124	C1
Egerman, K., Klaus, D.J., & Glaser, R. Decremental effects of reinforcement in teams with redundant members. Paper presented at the annual meeting of the American Psychological Association, September 1961. (DTIC No. AD 262 742)	123	C1
Egerman, K., Klaus, D.J., & Glaser, R. Increasing team proficiency through training. 2. Decremental effects of reinforcement in teams with redundant members (AIR-B64-6/62-TR). Pittsburgh, Pa.: American Institute for Research, June 1962. (DTIC No. AD 276 428)	123	C1

	Page	Section
Fiedler, F. E., & Meuwese, W. A. T. The leader's contribution to performance in cohesive and uncohesive task groups (Office of Naval Research Contract Nonr-1834(36), NR 177-472). Urbana, Ill.: University of Illinois, Department of Psychology, April 1962. (DTIC No. AD 729 820)	127	C2
Findlay, D. C., Matyas, S. M., & Rogge, H. Training achievement in basic combat squads with controlled aptitude (HumRRO Technical Report 16). Washington, D. C.: George Washington University, Human Resources Research Office, January 1955. (DTIC No. AD 073 777)	149	E1
Finley, D.L., Obermayer, R.W., Bertone, C.M., Meister, D., & Muckler, F.A. Human performance prediction in man-machine systems (Volume I). A technical review (NASA CR-1614). Canoga Park, Calif.: Bunker-Ramo Corp., August 1970. (STAR N70-35279)	74, 210	B,G
Finley, D.L., Obermayer, R.W., Bertone, C.M., Meister, D., & Muckler, F.A. Human performance prediction in man-machine systems (Volume III). A selected and annotated bibliography (NASA Contract No. NAS2-5038). Canoga Park, Calif.: Bunker-Ramo Corp., August 1969. (STAR N71-27251)	74, 210	B,G
Finley, D. L., Rheinlander, T. W., Thompson, E. A., & Sullivan, D. J. Training effectiveness evaluation of Naval training devices, Part I: A study of the effectiveness of a carrier air traffic control center training device (Technical Report, NAVTRAEQUIPCEN 70-C-0258-1). Westlake Village, Calif.: Bunker Ramo, Electronic Systems Division, August 1972. (DTIC No. AD 751 556)	150, 210	E1,G
Fleishman, E. A. The prediction of total task performance from prior practice on task components. Human Factors, 1965, 7, 18-27.	210	G
Fleishman, E. A. Toward a taxonomy of human performance. American Psychologist, 1975, 30, 1127-1140.	190	F

	Page	Section
Forgays, D. G., & Levy, B. I. <u>Combat performance characteristics associated with changes in the membership of medium-bomber crews</u> (AFPTRC-TN-57-130). San Antonio, Tex.: Lackland Air Force Base, Air Force Personnel and Training Research Center, December 1957. (DTIC No. AD 136 418)	96	C1
Gagne, R. M. Military training and principles of learning. <u>American Psychologist</u>, 1962, <u>17</u>, 83-91.	52	A
George, C. E. <u>Some determinants of small-group effectiveness</u> (HumRRO Research Memorandum No. 26). Ft. Benning, Ga.: U.S. Army Infantry Human Research Unit, May 1962 (revised October 1962). (DTIC No. AD 624 208)	52	A
George, C. E. Training for coordination within rifle squads. In T. O. Jacobs, J. S. Ward, T.R. Powers, C. E. George, & H. H. McFann (Eds.), <u>Individual and small-unit training for combat operations</u> (HumRRO Professional Paper 21-67). Alexandria, Va.: Human Resources Research Office, George Washington University, May 1967. (a) (DTIC No. AD 653 845)	151, 178	E1, E2
George, C. E. The view from the underside --- Task demands and group structure. In J. A. Olmstead, P. D. Hood, C. E. George, & T. O. Jacobs (Eds.), <u>Goal-directed leadership: Superordinate to human relations?</u> (HumRRO Professional Paper 11-67). Alexandria, Va.: Human Resources Research Office, March 1967. (b) (DTIC No. AD 649 864)	74, 152	B, E1
George, C. E. Testing for coordination in small units. <u>Proceeding of the Military Testing Conference</u>, 1977, <u>19</u>, 487-497.	191	F
George, C. E. <u>Team member coordination: Definition measurement, and effect on performance.</u> Lubbock, Tex.: Texas Tech University. Paper presented at Southeastern Psychological Association meeting, New Orleans, La., March 1979.	152	E1

	Page	Section
George, C. E., & Dudek, R. A. Performance, recovery and manmachine effectiveness: Final report on a basic research program under project THEMIS (Prepared for Army Human Engineering Laboratory). Lubbock, Tex.: Texas Tech University, April 1974. (DTIC No. AD 777 797)	97	C1
George, C. E., Hoak, G. R., & Boutwell, J. Pilot studies of team effectiveness (Research Memorandum No. 28). Ft. Benning, Ga.: U.S. Army Infantry Human Research Unit, Human Resources Research Office, February 1963. (DTIC No. AD 627 214)	97, 128	C1, C2
George Washington University Medical Center. Studies of social group dynamics under isolated conditions: Objective summary of the literature as it relates to potential problems of long duration space flight (NASA CR-2496). Washington, D.C.: Author, December 1974. (NTIS No. N75-15308)	53	A
Gill, D. L. Cohesiveness and performance in sport groups. In R. S. Yeeton (Ed.), Exercise and sports sciences review (Vol. 5). Santa Barbara, Calif.: Journal Publishing Affiliates, 1977.	53	A
Gill, D. L. The prediction of group motor performance from individual member abilities. Journal of Motor Behavior, 1979, 11(2), 113-122.	128	C2
Giordano, D. J., Ursin, D. J., Zubal, O., & Lutchendorf, T. E. Human Engineering Laboratory Mortar System Test: HELMST-1 (HEL Technical Memorandum 10-77). Aberdeen Proving Ground, Md.: U.S. Army Human Engineering Laboratory, April 1977. (DTIC No. AD B019 690L)	211	G
Glanzer, M., & Glaser, R. A review of team training problems (Prepared for Office of Naval Research). Pittsburgh, Pa.: American Institute for Research, September 1955. (DTIC No. AD 078 834)	192, 211	F,G
Glanzer, M., & Glaser, R. Techniques for the study of group structure and behavior. I: Analysis of structure. Psychological Bulletin, 1959, 56, 317-332.	193	F

	Page	Section
Glanzer, M. & Glaser, R. Techniques for the study of group structure and behavior. II. Empirical studies of the effects of structure in small groups. Psychological Bulletin, 1961, 58, 1-27. (DTIC No. AD 254 918)	54	A
Glanzer, M., Glaser, R., & Klaus, D. J. The team performance record: An aid for team analysis and team training (Technical Report, N7onr-37008, NR-154-079). Pittsburgh, Pa.: American Institute for Research, December 1956. (DTIC No. AD 123 615)	211	G
Glaser, R., Glanzer, M. & Morten, A. W. Jr. A study of some dimensions of team performance (AIR Technical Report, Office of Naval Research Contract N7onr-37008, NR-154-079). Pittsburgh, Pa.: American Institute for Research, September 1955. (DTIC No. AD 078 433)	191	F
Glaser, R., & Klaus, D.J. Proficiency measurement: Assessing human performance. In R.M. Gagne & A. W. Melton (Eds.), Principles in system development. New York: Holt, Rinehart & Winston, 1962.	212	G
Glaser, R.,& Klaus, D.J. A reinforcement analysis of group performance. Psychological Monographs: General and Applied, 1966, 80 (13, Whole No. 621). (DTIC No. AD 640 624)	123	C1
Glaser, R., & Klaus, D.J. Studies of the reinforcement components of group performance. From a symposium on the simulation of humman behavior. Paris, July 1967. (DTIC No. AD 708 587)	123	C1
Glaser, R., Klaus, D.J., & Egerman, K. Increasing team proficiency through training.2. The acquisition and extinction of a team response (AIR-B64-5/62-TR). Pittsburgh, Pa.: American Institute for Research, May 1962. (DTIC No. AD 276 429)	123	C1
Goldin, S.E., & Thorndyke, P.W. (Eds.) Improving team performance: Proceedings of the Rand team performance workshop (R-2606-ONR). Santa Monica, Calif.: Rand Corporation, August 1980.	228	I

	Page	Section
Goodacre, D. M. Group characteristics of good and poor performance combat units. <u>Sociometry</u>, 1953, <u>16</u>, 168–178.	138	D
Greenbaum, C.W. The small group under the gun: Uses of small groups in battle conditions. <u>Journal of Applied Psychology</u>, 1979, <u>15</u>, 392–405.	55	A
Greer, F.L. <u>Small group effectiveness</u> (Series 1955, Institute Report No. 6, Prepared for Office of Naval Research). Philadelphia, Pa.: Institute for Research in Human Relations, 1955. (ASTIA No. AD 92 042)	137	D
Greer, F.L., Galanter, E.H., & Nordlie, P.G. Interpersonal knowledge and individual and group effectiveness. <u>Journal of Abnormal and Social Psychology</u>, 1954, <u>49</u>, 411–414.	138	D
Guetzkow, H., & Simon, H.A. The impact of certain communication nets upon organization and performance in task-oriented groups. <u>Management Science</u>, 1955, <u>1</u>, 233–250.	98	C1
Hackman, J. R. <u>Tests, questionnaires and tasks of the group effectiveness research laboratory</u> (Technical Report No. 24, ONR Contract NR 177-472, NONR-1834 (36)). Urbana, Ill.: Group Effectiveness Research Laboratory, University of Illinois, July 1965. (DTIC No. AD 623 312)	224	H
Hackman, J. R. Effects of task characteristics on group products. <u>Journal of Experimental Social Psychology</u>, 1968, <u>4</u>, 162–187.	98	C1
Hackman, J. R. Toward understanding the role of tasks in behavioral research. <u>Acta Psychologica</u>, 1969, <u>31</u>, 97–128.	195	F
Hackman, J.R. <u>Improving individual and group performance effectiveness</u>. (Prepared for Office of Naval Research). New Haven, Conn.: Yale University, 1979. (DTIC No. AD A077 892)	55	A

	Page	Section
Hackman, J. R., Brousseau, K. R., & Weiss, J. A. The interaction of task design and group performance strategies in determining group effectiveness. *Organizational Behavior and Human Performance*, 1976, *16*, 350-365.	99	C1
Hackman, J. R., & Morris, C. G. Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 8). New York: Academic Press, 1975, pp. 45-99. (DTIC No. AD 785 287)	75, 228	B, I
Hackman, J. R., & Vidmar, N. Effects of size and task type on group performance and member reactions. *Sociometry*, 1970, *33*, 37-53. (DTIC No. AD 706 820)	100	C1
Hackman, J. R., Weiss, J. A., & Brousseau, K. R. *Effects of task performance strategies on group performance effectiveness* (Prepared for Office of Naval Research). New Haven, Conn.: Yale University, October 1974. (DTIC No. AD A001 707)	100	C1
Haines, D. B. *Training for group interdependence* (AMRL-TR-65-117). Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratories, Air Force Systems Command, July 1965. (DTIC No. AD 623 119)	56	A
Hall, E. R., & Rizzo, W. A. *An assessment of U. S. Navy tactical team training* (TAEG Report No. 18). Orlando, Fla.: Training Analysis and Evaluation Group, March 1975. (DTIC No. AD A011 452)	56	A
Hallam, J., & Stammers, R.B. The effects of task characteristics on the organisation of the team. In R. C. Sugarman (Ed.), *Proceedings of the Human Factors Society 25th Annual Meeting*. Santa Monica, Calif.: Human Factors Society, 1981, p. 546-550.	102	C1
Hammell, T.J. & Mara, T.D. *Application of decision making and team training research to operational training: A translative technique. Final Report* (TR NAVTRADEVCEN 68-C-0242-1). Orlando, Fla.: Naval Training Device Center, April 1970. (DTIC No. AD 871 924)	196	E

	Page	Section
Harris, J. H., Campbell, R. C., Osborn, W. C., & Boldovici, J. A. Development of a model job performance test for a combat occupational speciality (Volume I). Test development (Final Report, FR CD(L)-75-6). Alexandria, Va.: Human Resources Research Organization, November 1975. (DTIC No. AD A025 192)	212	G
Havron, M. D., Gorham, W. A., Nordlie, P. G., & Bradford, R. G. Tactical training of the Infantry rifle squad (HumRRO Technical Report 18). Washington, D. C.: Psychological Research Associates, George Washington University, June 1955.	153, 213	E1,G
Havron, M. D., & McGrath, J. E. The contribution of the leader to the effectiveness of small military groups. In L. Petrullo & B. M. Bass (Eds.), Leadership and interpersonal behavior. New York: Holt Rinehart & Winston, 1961, pp. 167-178.	102, 128, 155	C1,C2, E1
Havron, M.D., and others. Improved Army Training and Evaluation Program (ARTEP) methods for unit evaluation (7 vols.). (ARI Technical Reports TR-78-A23 through TR-78-A29). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, 1978-1979.	213	G
Helm, W. R. Function description inventory as a human factors test and evaluation tool: An empirical validation study (Fourth interim report). Patuxent River, Md.: Naval Air Test Center, July 20, 1976. (DTIC No. AD B013 189)	197	F
Henriksen, K.F., Jones, D.R., Hannaman, D.L., Wylie, P.B., Shriver, E.L., Hamill, B.W., & Sulzen, R.H. Identification of combat unit leader skills and leader-group interaction processes (ARI Technical Report 440). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1980.	76, 198	B,F
Heslin, R. Predicting group task effectivenesss from member characteristics. Psychological Bulletin, 1964, 62, 248-256.	56	A

Reference	Page	Section
Hewett, T. T., O'Brien, G. E., & Hornik, J. The effects of work organization, leadership style, and member compatibility upon the productivity of small groups working on a manipulative task. Organizational Behavior and Human Performance, 1974, 11, 283-301. (DTIC No. AD A001 364)	103	C1
Honigfeld, A. R. Group behavior in confinement: Review and annotated bibliography (Technical Memorandum 14-65). Aberdeen Proving Ground, Md.: U. S. Army Human Engineering Laboratories, October 1965. (DTIC No. AD 640 161)	57	A
Hood, P. D., and others. Conference on integrated aircrew training (WADD Technical Report 60-320). Wright-Patterson Air Force Base, Ohio: Air Research and Development Command, Wright Air Development Division, July 1960. (DTIC No. AD 240 688)	57, 198, 228	A,F,I
Horley, G. L., & Giordano, D. J. Human Engineering Laboratories Battalion Artillery Test: HELBAT I (HEL Technical Memorandum 24-70). Aberdeen Proving Ground, Md.: Human Engineering Laboratories, September 1970.	213	G
Horrocks, J. E., Heermann, E., & Kalk, M. A study of selected factors affecting the measurement of total team product in gunfire support training (Technical Report: NAVTRADEVCEN 1939-0-4). Columbus, Ohio: Ohio State University Research Foundation, November 1959. (DTIC No. AD 643 830)	214	G
Horrocks, J. E., Heermann, E., & Krug, R. E. Team training III: An approach to optimum methods and procedures (Technical Report, NAVTRADEVCEN 198-3). Columbus, Ohio: Ohio State University, August 1961. (DTIC No. AD 267 666)	103	C1
Horrocks, J. E., Krug, R. E., & Heermann, E. Team training II: Individual learning and team performance (Technical Report, NAVTRADEVCEN 198-2). Columbus, Ohio: Ohio State University, Research Foundation, August 1960. (DTIC No. AD 247 187)	104	C1

	Page	Section
HumRRO. STAF selection procedures (HumRRO RBP-04-71-35). Alexandria, Va.: Human Resources Research Organization, HumRRO Division No. 4, Ft. Benning, Ga., December 1971.	224	H
HumRRO. Training for small independent action forces (SIAF). Alexandria, Va.: Human Resources Research Organization, HumRRO Division No. 4, Fort Benning, Ga., undated (about 1970).	178	E2
Jacobs, T. O. Leadership in small military units (HumRRO Professional Paper 42-68). Washington, D. C.: George Washingon University, Human Resources Research Office, December 1968. (DTIC No. AD 682 349)	155, 198	E1,F
Jacobs, T. O., Rahn, R. C., & Moore, C. B. Instructor's guide: Basic problems in small-unit leadership. Ft. Benning, Ga.: Human Resources Research Organization, Division No. 4, April 1965. (DTIC No. AD B000 670L)	155	I
Johnston, W. A. Transfer of team skills as a function of type of training. Journal of Applied Psychology, 1966, 50, 102-108.	166	E1
Johnston, W. A. & Briggs, G. E. Team performance as a function of task arrangement and work-load. Journal of Applied Psychology, 1968, 52, 89-94.	105	C1
Johnston, W. A., & Howell, W. C. The effect of team feedback on individual performance and self evaluation (Final Report, Grant No. AF-AFOSR-985-66). Columbus, Ohio: Ohio State University, Human Performance Center, September 1966. (DTIC No. AD 640 404)	105	C1
Johnston, W. A., & Nawrocki, L. H. The effect of simulated team feedback on the performance of good and poor trackers (Technical Report: AFOSR-66-2541). Columbus, Ohio: Ohio State University, Human Performance Center, November 1966. (DTIC No. AD 644 480)	106	C1
Jones, M. B. Regressing group on individual effectiveness. Organizational Behavior and Human Performance, 1974, 11, 426-451.	128	C2

	Page	Section
Jones, F.E., & Odom, W.F. Moonlight II: Training the Infantry soldier to fire the M1 rifle at night (HumRRO Technical Report 15). Washington, D.C.: George Washington University, Human Resources Research Office (Human Research Unit No. 3, Ft. Benning, Georgia), December 1954.	179	E2
Jordan, N., Jensen, B. T., & Terebinsky, S. J. The development of cooperation among three-man crews in a simulated man-machine information processing system. Journal of Social Psychology, 1963, 59, 175-184.	78	B
Jacobs, T. O. Basic problems in small-unit leadership. Fort Benning, Ga.: HumRRO Division No. 4, April 1956. (DTIC No. AD 637 727)	224	H

	Page	Section
Kabanoff, B., & O'Brien, G. E. The effects of task type and cooperation upon group products and performance. *Organizational Behavior and Human Performance*, 1979, *23*, 163-181.	106	C1
Kent, R.N., & McGrath, J.E. Task and group characteristics as factors influencing group performance. *Journal of Experimental Social Psychology*, 1969, *5*, 429-440.	106	C1
Kidd, J. S. A comparison of one-, two-, and three-man work units under various conditions of work load. *Journal of Applied Psychology*, 1961, *45*, 195-200.	107	C1
Kidd, J. S. Work team effectiveness as a function of mechanical degradation of the intrateam communication system. *Journal of Engineering Psychology*, 1963, *2*, 1-14.	107, 155	C1,E1
Kidd, J. S., & Hooper, J. J. *Division of responsibility between two controllers and load balancing flexibility in a radar approach control team: A study in human engineering aspects of radar air control* (WADC Technical Report 58-473). Columbus, Ohio: Ohio State University, Laboratory of Aviation Psychology, April 1959. (DTIC No. AD 214 616)	107	C1
King, F., Stein, F.S., Sevilla, E.R., & Seed, R.J. *Artillery engagement simulation* (ARI Technical Report 1245). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, May 1980.	214	G
Kinkade, R. G., & Kidd, J. S. *The effect of team size and intermember communication on decision-making performance* (WADC Technical Report 58-474). Wright-Patterson Air Force Base, Ohio: AERO Medical Laboratory, April 1959. (DTIC No. AD 215 521)	108	C1
Klaus, D.J., & Glaser, R. *Increasing team proficiency through training. 5. Team learning as a function of member learning characteristics and practice conditions* (AIR-E1-4/65-TR). Pittsburgh, Pa.: American Institutes for Research, May 1965. (DTIC No. AD 471 469)	125, 129	C1,C2

	Page	Section
Klaus, D.J., & Glaser, R. *Increasing team proficiency through training. 8. Final summary report* (AIR-E1-6/68-FR). Pittsburgh, Pa.: American Institutes for Research, May 1968. (DTIC No. AD 669 689)	122	C1
Klaus, D.J., & Glaser, R. Reinforcement determinants of team proficiency. *Organizational Behavior and Human Performance*, 1970, *5*, 33-67. (DTIC No. AD 708 242)	122	C1
Klaus, D.J., Grant, L.D., & Glaser, R. *Increasing team proficiency through training. 6. Supervisory furnished reinforcement in team training* (AIR-EI-5/65-TR). Pittsburgh, Pa.: American Institutes for Research, May 1965. (DTIC No. AD 471 470)	125	C1
Klingberg, C. L., Gonzalez, B. K., & Jones, H. H. *Effects of work pacing and teaming on interpreter performance*. Seattle, Wash.: Boeing Co., 1967. (DTIC No. AD 848 522)	108	C1
Knerr, C.M., Berger, D.C., & Popelka, B.A. *Sustaining team performance: A systems model* (ARPA Contract No. MDA903-79-C-0209). Springfield, Va.: Mellonics Systems Development Division, March 1980.	59, 78	A,B
Knerr, C.M., Nadler, L.B., & Berger, L.E. *Toward a Naval team taxonomy* (Interim Report, ONR Contract No. N0014-80-C-0871). Arlington, Va.: Mellonics Systems Development Division, December 1980.	60, 198	A,F
Knerr, C. M., Root, R. T., & Word, L. E. *An application of tactical engagement simulation for unit proficiency measurement* (ARI Technical Paper 381). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.	215	G
Kraemer, R.E., & Kristiansen, D.M. *A prototype crew drills training program for XM1 tank gunnery: Company commander's manual* (ARI Research Product 79-17). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, Ft. Knox Field Unit, November 1979. (DTIC No. AD A078 499)	180	E2

Reference	Page	Section
Kress, G., & McGuire, W.J. *Implementation and evaluation of the tank crew training program for USAREUR units* (ARI Research Note 79-40). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1979.	180	E2
Kubala, A. L. *Problems in measuring team effectiveness* (HumRRO Professional Paper 2-78). Alexandria, Va.: Human Resources Research Organization, January 1978. (DTIC No. AD A049 560)	215	G
Lange, C. J. *Leadership in small military units: Some research findings* (HumRRO professional Paper 24-67). George Washington University, Washington, D. C.: George Washington University, Human Resources Research Office, June 1967. (DTIC No. AD 654 345)	139	D
Lange, C.J., & Jacobs, T.O. *Leadership in Army Infantry platoons: Study II* (HumRRO Research Report 5). Alexandria, Va.: George Washington University, Human Resources Research Office, July 1960. (DTIC No. AD 240 895)	224	H
Lanzetta, J. T., & Roby, T. B. Effect of work-group structure and certain task variables on group performance. *Journal of Abnormal and Social Psychology*, 1956, *53*, 307-314. (a)	109	C1
Lanzetta, J. T., & Roby, T. B. Group performance as a function of work-distribution patterns and task load. *Sociometry*, 1956, *19*, 95-104. (b)	110	C1
Larson, O. A., & Sander, S. T. *Development of unit performance effectiveness measures using Delphi procedures* (NPRDC TR 72-12). San Diego, Calif.: Navy Personnel Research and Development Center, September 1975. (DTIC No. AD A015 963)	216	G
Laughlin, P.R., & Johnson, H.H. Group and individual performance on a complementary task as a function of initial ability level. *Journal of Experimental Social Psychology*, 1966, *2*, 407-418.	129	C2

	Page	Section
Leavitt, H.J. Some effects of certain communication patterns on group performance. Journal of Abnormal and Social Psychology, 1951, 46, 38-50.	111	C1
Lord, R.G. Group performance as a function of leadership behavior and task structure: Toward an explanatory theory. Organizational Behavior and Human Performance, 1976, 17, 76-96.	111, 129, 198	C1, C2, F
Lorge, I., Fox, D., Davitz, J., & Brenner, M. A survey of studies contrasting the quality of group performance and individual performance, 1920-1957. Psychological Bulletin, 1958, 55, 337-372.	62	A
Lowe, R. H., & McGrath, J. E. Prediction of characteristics of group output from individual performance characteristics (AFORS-69-2470TR). Urbana, Ill.: University of Illinois, Department of Psychology, August 1969. (DTIC No. AD 700 103)	78	B
Marra, H. A. A comparative analysis of group reinforcement contingencies. San Francisco, Calif.: Letterman Army Institute of Research, U. S. Army Medical Research and Development Command, September 1971. (NTIS No. AD 738 854)	112	C1
McDaniel, W. T., & Dodd, J. R. Minuteman combat crew integrity: Its effect on job satisfaction and job performance (Master's thesis). Wright-Patterson Air Force Base, Ohio: Air University, September 1972. (DTIC No. AD 750 850)	112	C1
McGrath, J.E. Assembly of quasi-therapeutic rifle teams (Technical Report No. 13). Urbana, Ill.: University of Illinios, Department of Psychology, Group Effectiveness Research Laboratory, July 1961. (DTIC No. AD 689 204)	139, 225	D, H
McGrath, J.E., & Altman, I. Small group research: A synthesis and critique of the field. New York: Holt Rinehart & Winston, 1966.	62, 230	A, I

	Page	Section
McGuire, W.J., & Kress, G. Tank platoon training program outline for USAREUR units (ARI Research Report 1230). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, February 1980.	181	E2
McKay, J. G., Cianci, S., Hall, C. E., & Taylor, J. E. Some factors which have contributed to both successful and unsuccessful American infantry small-unit actions (HumRRO Research Memorandum No. 13). Ft. Benning, Ga.: U.S. Army Infantry Human Research Unit, April 1959. (DTIC No. AD 260 994)	140	D
McRae, A. V. Interaction content and team effectiveness (HumRRO Technical Report 66-10). Alexandria, Va.: Human Resources Research Office of the George Washington University, HumRRO Division No. 4, June 1966. (DTIC No. AD 637 311)	140, 199	D,F
Medlin, S.M. Behavioral forecasting for REALTRAIN combined arms (ARI Technical Paper 365). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, May 1979.	216	G
Medlin, S.M., & Thompson, P. Evaluator rating of unit performance in field exercises: A multidimensional scaling analysis (ARI Technical Report 438). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, April 1980.	217	G
Meliza, L.L., Scott, T.D., & Epstein, K.I. REALTRAIN validation of rifle squads II: Tactical performance (ARI Research Report 1203). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, March 1979.	169, 199	E1,F
Meister, D. Behavioral foundations of system development. New York: Wiley, 1976.	64, 231	A,I
Miller, D. T. Skill dilution and skill level requirements as determinants of crew performance. Doctoral Dissertation, Texas Tech University, 1971. (DTIC No. AD 734 192)	113	C1

	Page	Section
Miller, F. B. "Situational" interactions --- A worthwhile concept? *Human Organization*, 1958, *17*, 37-47.	199	F
Mirabella, A. *Criterion-referenced system approach to evaluation of combat units* (*ARI Research Memorandum 78-21*). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978.	217	G
Mitchell, T. R. *Cognitive complexity and group performance*. Seattle, Wash.: University of Washington, Department of Psychology, 1970. (NTIS No. AD 765 001)	130	C2
Moore, H. G. *The effects of load and accessibility of information upon performance of small teams* (*AFOSR-1636*), Ann Arbor, Mich.: University of Michigan, October 1961. (DTIC No. AD 268 462)	113	C1
Morgan, B. B., Coates, G. D., Alluisi, E. A., & Kirby, R. H. *The team-training load as a parameter of effectiveness for collective training in units* (ITR-78-14). Norfolk, Va.: Old Dominion University, May 1978. (DTIC No. AD A063 135)	114, 181	C1,E2
Morrissette, J.O., Hornseth, J.P., & Shellar, K. Team organization and monitoring performance. *Human Factors*, 1975, *17*, 296-300.	115	C1
Morrissette, J.O., Jahnke, J.C., Baker, K., & Rohrman, N. Degree of structural balance and group effectiveness. *Organizational Behavioral and Human Performance*, 1967, *2*, 383-393.	130	C2
Mumford, S.J. *Human resource management and operational readiness as measured by refresher training on Navy ships* (NPRDC TR 76-32). San Diego, Calif.: Navy Personnel Research and Development Center, February 1976. (DTIC No. AD A022 272)	141	D
Nadler, D.A. The effects of feedback on task group behavior: A review of the experimental research. *Organizational Behavior and Human Performance*, 1979, *23*, 309-338.	66	A

	Page	Section
Naylor, J. C., & Briggs, G. E. Team-training effectiveness under various conditions. *Journal of Applied Psychology*, 1965, *49*, 223-229.	164	E1
Naylor, J. C., & Dickinson, T. L. Task structure, work structure, and team performance. *Journal of Applied Psychology*, 1969, *53*, 167-177.	79	B
Nebeker, D. M., Dockstader, S. L., & Vickers, R. R. *A comparison of the effects of individual and team performance feedback upon subsequent performance* (NPRDC TR 75-35). San Diego, Calif.: Navy Personnel Research and Development Center, May 1975. (NTIS No. AD A010 131)	115	C1
Nelson, P. D., & Berry, N. H. Cohesion in Marine recruit platoons. *Journal of Psychology*, 1968, *68*, 63-71. (DTIC No. AD 667 615)	225	H
Nieva, V.F., Fleishman, E.A., & Rieck, A. *Team dimensions: Their identity, their measurement and their relationships*. Washington, D.C.: Advanced Research Resources Organization, November 1978.	66, 200	A,F
Obermayer, R. W., & Vreuls, D. *Combat-ready crew performance measurement system: Phase IIIA, Crew performance measurement.* (AFHRL-TR-74-108(IV)). Northridge, Calif.: Manned Systems Sciences, December 1974. (DTIC No. AD B005 520)	200	F
Obermayer, R.W., Vreuls, D., Muckler, F.A., Conway, E.J., & Fitzgerald, J.A. *Combat-ready crew performance measurement system: Final report* (AFHRL-TR-74-108(I)). Brooks Air Force Base, Tex.: Air Force Systems Command, December 1974. (DTIC No. AD B005 517)	200	F
O'Brien, G. *Methods of analyzing group tasks* (Technical Report No. 46). Urbana, Ill.: Department of Psychology, Group Effectiveness Research Laboratory, January 1967. (DTIC No. AD 647 762)	201	F

	Page	Section
O'Brien, G. The measurement of cooperation. Organizational Behavior and Human Performance, 1968, 3, 427-439.	201	F
O'Brien, R.E., Crum, W.J., Healy, R.D., Harris, J.H., & Osborn, W.C. Trial implementations of the tank crewman skills training program (TCST) (ARI Technical Report 78-A29). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978. (DTIC No. AD A061 226)	156, 181	E1,E2
O'Brien, R. E., Kraemer, R. E., & Haggard, D. F. Procedures in the derivation of mission-relevant unit task statements (HumRRO TR 75-4). Alexandria, Va.: Human Resources Research Organization, May 1975. (DTIC No. AD A012 673)	218	G
O'Brien, G. E., & Owens, A. G. Effects of organizational structure upon correlations between member abilities and group productivity (Technical Report No. 75 (69-4), Prepared for Office of Naval Research). Urbana, Ill.: University of Illinois, Department of Psychology, Group Effectiveness Research Laboratory, June 1969. (DTIC No. AD 692 407)	115, 131	C1,C2
Olmstead, J. A., Powers, T. R., Caviness, J. A., & Maxey, J. L. Selection and training for small independent action forces: Development of materials and procedures (HumRRO Technical Report 71-17). Alexandria, Va.: Human Resources Research Organization, August 1971.	218	G
Popelka, B.A., & Knerr, C.M. Team training applications of voice processing technology (Final Report, ARPA Contract No. MDA903-79-C-0209). Springfield, Va.: Litton Mellonics Systems Development Division, March 1980. (DTIC No. AD A095 099/1)	231	I
Pritchard, R.D., & Montagno, R.V. Effects of specific vs. nonspecific and absolute vs. comparative feedback on performance and satisfaction (AFHRL-TR-78-12). West Lafayette, Ind.: Purdue Research Foundation, May 1978. (DTIC No. AD A055 693)	116	C1

	Page	Section
Prophet, W.W., & Caro, P.W. Simulation and aircrew training and performance. In *Proceedings of the conference on aircrew performance in Army aviation*. U.S. Army Research Institute for the Behavioral and Social Sciences, July 1974, pp. 130-136. (DTIC NO. AD A001 539)	157	E1
Roby, T. B. On the measurement and description of groups. *Behavioral Science*, 1957, *2*, 119-127.	201	F
Roby, T.B. *Small group performance*. Chicago: Rand McNally, 1968.	79	B
Roby, T. B. & Lanzetta, J. T. *A replication study of work group structure and task performance*. Lackland Air Force Base, Tex.: Air Force Personnel and Training Research Center, June 1957. (a) (DTIC No. AD 134 205)	202	F
Roby, T. B., & Lanzetta, J. T. Conflicting principles in man-machine system design. *Journal of Applied Psychology*, 1957, *41*(3), 170-178. (b)	117	C1
Roby, T. B. & Lanzetta, J. T. Considerations in the analysis of group tasks. *Psychological Bulletin*, 1958, *55*(2), 88-101.	202	F
Root, R.T., Epstein, K.I., Steinheiser, F.H., Hayes, J.F., Wood, S.E., Sulzen, R.H., Burgess, G.G., Mirabella, A., Erwin, D.E., & Johnson, E. *Initial validation of REALTRAIN with Army combat units in Europe*. (ARI Research Report 1191). Arlington, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, October 1976. (DTIC No. AD A034 610)	168	E1
Root, R.T., Hayes, J.F., Word, L.E., Shriver, E.L., & Griffin, G.R. *Field test of techniques for tactical training of junior leaders in Infantry units* (Project EFFTRAIN) (ARI Technical Report TR-79-A21). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.	157	E1

	Page	Section
Root, R.T., Knerr, C.M., Severino, A.A., & Word, L.E. *Tactical engagement simulation training: A method for learning the realities of combat* (ARI Technical Paper 370). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1979.	203	F
Sanders, M. B., Hofmann, M. A., Harden, D. F., & Frezell, T. L. *Communication during terrain flight* (USAARL Report 75-13). Fort Rucker, Ala.: Army Aeromedical Research Laboratory, March 1975. (NTIS No. AD A009 336).	141	D
Schrenk, L.P., Daniels, R.W., & Alden, D.G. *Study of long-term skill retention* (NAVTRADEVCEN Technical Report 1822-1). St. Paul, Minn.: Honeywell, April 1969. (DTIC No. AD 503 679)	158, 182, 219	E1, E2, G
Schwartz, S. *Tank crew effectiveness in relation to the supervisory behavior of the tank commander* (HumRRO Technical Report 68-12). Alexandria, Va.: Human Resources Research Office, September 1968. (DTIC No. AD 679 013)	131	C2
Scott, T. D. Tactical training for ground combat forces. *Armed Forces and Society*, 1980, *6*(2), 215-231.	171	E1
Scott, T.D., Meliza, L.L., Hardy, G.D., & Banks, J.H. *Armor/anti-armor team tactical performance* (ARI Research Report 1218). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.	170, 203	E1,F
Scott, T.D., Meliza, L.L., Hardy, G.D., Banks, J.H., & Word, L.E. *REALTRAIN validation for armor/anti-armor teams* (ARI Research Report 1204). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, March 1979.	170	E1
Sells, S. B. *Military small group performance under isolation and stress, Critical review II. Dimensions of group structure and group behavior* (Technical Documentary Report AAL-TDR-62-33). Fort Wainwright, Alaska: Arctic Aeromedical Laboratory, June 1962. (DTIC No. AD 288 688)	67	A

	Page	Section
Shaw, M. E. *Scaling group tasks: A method for dimensional analysis* (ONR Contract NR 170-266, Nonr-580(11)). Gainesville, Fla.: University of Florida, July 1963. (DTIC No. AD 415 033)	203	F
Shaw, M.E. *Group dynamics: The psychology of small group behavior* (2nd ed.). New York: McGraw-Hill, 1976.	81	B
Shaw, M.E., & Blum, J.M. Effects of leadership style upon group performance as a function of task structure. *Journal of Personality and Social Psychology*, 1966, *3*, 239-242. (DTIC No. AD 605 854)	131	C2
Shiflett, S. Toward a general model of small group productivity. *Psychological Bulletin*, 1979, *86*, 67-79.	82	B
Shirom, A. On some correlates of combat performance. *Administrative Science Quarterly*, 1976, *21*, 419-432.	142	D
Short, J.G., Cotton, T.S., & Klaus, D.J. *Increasing team proficiency through training. 7. The simulation of team environments* (AIR-E1-5/68-TR). Pittsburgh, Pa.: American Institutes for Research, May 1968. (DTIC No. AD 669 687)	125	C1
Shriver, E.L., Griffin, G.R., Hannaman, D.L., & Jones, D.R. *Small combat arms unit leader training techniques: Rules of play for two player/multiplayer Infantry mapboard games* (ARI Research Product 79-4). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1979.	182	E2
Shriver, E.L., Henriksen, K.F., Jones, D.R., & Onoszko, P.W.J. *Development of a leader training model and system* (ARI Research Note 80-3). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1980.	82, 183	B, E2

	Page	Section
Shriver, E.L., Jones, D.R., Hannaman, D.L., Griffin, G.R., & Sulzen, R.H. Development of small combat arms unit leader tactical training techniques and a model training system (ARI Research Report 1210). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, July 1979.	159	E1
Shure, G.H., Rogers, M.S., Larsen, I.M., & Tassone, J. Group planning and task effectiveness. Sociometry, 1962, 25, 263-282.	119	C1
Siegel, A. I., & Federman, P. J. Communications content training as an ingredient in effective team performance. Ergonomics, 1973, 16, 403-416. (For earlier version of report, see Siegel, A. I., & Federman, P. J. Increasing ASW helicopter effectiveness through communications training (Technical Report: NAVTRADEVCEN 66-C-0045-1). Wayne, Pa.: Applied Psychological Services, October 1968. (DTIC No. AD 682 408)	169, 204	E1,F
Siegel, A. I., & Miehle, W. Post-training performance criterion development and application: Extension of a prior personnel subsystem reliability determination technique (ONR contract, Nonr-2270(00)). Wayne, Pa.: Applied Psychological Services, June 1967. (DTIC No. AD 654 221)	84	B
Siegel, A. I., Wolf, J. J., & Consentino, J. Digital simulation of the performance of intermediate size crews: Application and validation of a model for crew simulation (Office of Naval Research contract N00014-68-C-0262). Wayne, Pa.: Applied Psychological Services, February 1971. (DTIC No. AD 720 354)	84	B
Siegel, A. I., Wolf, J. J., & Fischl, M. A. Digital simulation of the performance of intermediate size crews. I. Logic of a model for simulating crew psychosocial and performance variables. (Prepared for Office of Naval Research). Wayne, Pa.: Applied Psychological Services, September 1969. (DTIC No. AD 695 939)	84	B

	Page	Section
Siskel, M., Lane, F. D., Powe, W. E., & Flexman, R. E. Intra-crew communication of B-52 and KC-135 student and combat crews during selected mission segments (AMRL-TR-65-18). Wright-Patterson Air Force Base, Ohio: Air Force Systems Command, Aerospace Medical Research Laboratory, May 1965. (DTIC No. AD 617 598)	143	D
Smode, A.F., Gruber, A., & Ely, J.H. The measurement of advanced flight vehicle crew proficiency in synthetic ground environments (MRL-TDR-62-5, Prepared for Air Force Systems Command, Behavioral Sciences Laboratory). Stamford, Conn.: Dunlap & Assoc., 1962. (DTIC No. AD 273 449)	219	G
Sorenson, J.R. Task demands, group interaction and group performance. Sociometry, 1971, 34, 483-495.	119, 204	C1,F
Sorenson, J.R. Group member traits, group process, and group performance. Human Relations, 1973, 26, 639-655.	225	H
Steiner, I. D. Models for inferring relationships between group size and potential group productivity. Behavioral Science, 1966, 11, 273-283.	85	B
Steiner, I. D. Group process and productivity. New York: Academic Press, 1972.	67, 85	A,B
Stokes, J.W., & Banderet, L.E. A war for science. Field Artillery Journal, 1978, Jan-Feb, 43-44.	172, 205, 222	E1,F, G
Sulzen, R. H. The effects of repeated engagement simulation exercises on individual and collective performance (Paper presented at American Educational Research Association annual meeting, Boston, Mass.). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, April 1980.	220	G

	Page	Section
Sulzen, R.H. & Bleda, P.R. Effects of combat simulation on the work-related motivation/satisfaction of participants (ARI Technical Paper 351). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, March 1979.	171	E1
Taylor, James R. Modeling the task group as a partially self-programming communication net: A cybernetic approach to the study of social processes at the small group level. In K. Krippendorf (Ed.), Communication and control in society. New York: Gordon and Breach, 1979, pp. 407-421.	85	D
Terborg, J. T., Castore, C. H., & DeNinno, J. A. A longitudinal field investigation of the impact of group performance and cohesion (Office of Naval Research Organizational Effectiveness Research Programs Contract No. N00014-67-A-0226). Lafayette, Ind.: Purdue University, May 1975. (DTIC No. AD A003 909)	132	C2
Thibaut, J.W., & Kelley, H.H. The social psychology of groups. New York: Wiley, 1959.	86, 204	B,F
Thorndyke, P.W., & Weiner, M.G. Improving training and performance of Navy teams: A design for a research program (R-2607-ONR). Santa Monica, Calif.: Rand Corporation, July 1980. (DTIC No. AD A089 092/1)	232	I
Thurmond, P., & Kribs, H. D. Computerized collective training for teams. Final report (ARI Technical Report TR-78-A1). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, February 1978. (DTIC No. AD A050 890)	161	E1
Torrance, E.P. Crew performance in a test situation as a predictor of field and combat performance (HFORL Report No. 33). Washington, D.C.: Bolling Air Force Base, Human Factors Operations Research Laboratories, Air Research and Development Command, March 1953. (a) (DTIC No. AD 014 473)	143	D

	Page	Section
Torrance, E. P. Methods of conducting critiques of group problem-solving performance. *Journal of Applied Psychology*, 1953, *37*, 394-398. (b) (DTIC No. AD 094 178)	120	C1
Trow, D. B. *Teamwork under turnover and succession* (Technical Report No. 2, Office of Naval Research contract Nonr 3679 (00), project NR 170-331). Endicott, N.Y.: Harpur College, June 1964. (DTIC No. AD 601 816)	120, 132	C1,C2
Tuckman, B.W. Developmental sequence in small groups. *Psychological Bulletin*, 1965, *63*, 384-399.	87	B
Tuckman, B.W. Group composition and group performance of structured and unstructured tasks. *Journal of Experimental Social Psychology*, 1967, *3*, 25-40.	120, 132	C1,C2
Turney, J.R., Cohen, S.L., & Greenberg, L. *Targets for team skills training* (Prepared for Office of Naval Research). Columbia, Md.: General Physics Corporation, April 1981. (DTIC No. AD A099 333)	68	A
Wagner, H., Hibbits, N., Rosenblatt, R. D., & Schulz, R. *Team training and evaluation strategies: State-of-the-art* (HumRRO TR-77-1). Alexandria, Va.: Human Resources Research Organization, February 1977. (DTIC No. AD A038 505)	69, 233	A,I
Warnick, W.L., & Kubala, A.L. *A study of selected problems in armor operations* (ARI Technical Report 78-A35). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, November 1978. (DTIC No. AD A065 938)	220	G
Warnick, W. L., O'Brien, R. E., Kraemer, R. E., Healy, R. D., & Campbell, R. C. *The validation of the task inventory of the tank company, platoon, and crew and the development of conditions and standards of the task inventory*. (Vols. I and II, HumRRO RP-D2-73-4). Alexandria, Va.: Human Resources Research Organization, June 1974. (NTIS Nos. AD A015 599 and AD A015 600)	204, 221	F,G

	Page	Section
Wheaton, G. R. Development of a taxonomy of human performance: A review of classificatory systems relating to tasks and performance (AIR-726-12/68/TR-1, Prepared for Advanced Research Projects Agency). Washington, D.C.: American Institute for Research, December 1968. (DTIC No. AD 689 411)	205	F
Wheaton, G.R., Fingerman, P.W., & Boycan, G.G. Development of a model tank gunnery test (ARI TR-78-A24). Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1978. (DTIC No. AD A061 153)	221	G
Williges, R. C., Johnston, W. A., & Briggs, G.E. Role of verbal communication in teamwork. Journal of Applied Psychology, 1966, 50, 473-478.	121, 205	C1,F
Zajonc, R. B. The effects of feedback and group task difficulty on individual and group performance (Technical Report No. 15, Prepared for Office of Naval Research). Ann Arbor, Mich.: Institute for Social Research, University of Michigan, November 1961. (DTIC No. AD 269 589)	121	C1
Zajonc, R.B. The requirements and design of a standard group task. Journal of Experimental Social Psychology, 1965, 1, 71-88. (DTIC No. AD 613 115)	87	B
Zander, A.F. Group aspiration and the desire for group achievement (Final Report, AFOSR 70-0528TR). Ann Arbor, Mich.: University of Michigan, March 1970. (DTIC No. AD 706 423).	133	C2
Ziller, R.C. The effects of changes in group composition on group performance. Final report (Grant No. AFOSR 62-05). Newark, Del.: University of Delaware, 1963. (DTIC No. AD 413 065)	122	C1
Ziller, R.C., Behringer, R.D., & Hawkins, C.E. Esprit, group dynamics, and motivation (Research Memorandum 63-6). Newark, Del.: University of Delaware, Center for Research on Social Behavior, April 1963. (DTIC No. AD A079 225)	133	C2